SOCIO-ECONOMIC EVALUATION OF IMPROVED FORAGE TECHNOLOGIES IN SMALLHOLDER DAIRY CATTLE FARMING SYSTEMS IN SOROTI DISTRICT, UGANDA

BY

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DECLARATION

I, Alice Turinawe, hereby declare that, to the best of my knowledge and understanding, the originality of the findings in this thesis is my work, and has never been presented in Makerere University or any other university for the award of a degree. However, any sources of information are duly acknowledged. This thesis has been submitted with permission from university supervisors.

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DEDICATION

I dedicate this thesis to Mr. Silver and Mrs. Angelic Baguma. And to Herbert

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

ABSTRACT

Smallholder dairy cattle producers in Uganda face major production constraints including inadequate and poor quality feeds. This has led to low milk yield, long calving intervals and low growth rates. Forage technologies have been widely recommended to alleviate this problem. However, farmers are only expected to take them up if it is profitable to do so. Thus, this study aimed at comparing the profitability of dairy cattle enterprises using improved forage technologies (IFT) with those using local technologies, determining the factors affecting the use of improved forage technologies among smallholder dairy farmers in Soroti District and comparing the factors responsible for profitability of dairy cattle enterprises using improved forage technologies with those using local technology. Data were collected on a random sample of 121 farmers from two purposively selected sub-counties in Soroti district. The analytical tools used included descriptive statistics, partial budget analyses, the probit model, and the Ordinary Least Squares (OLS).

Results indicated that farmers using IFT had significantly ($p<0.01$) larger gross margin with lower cost of production than those using local feeding methods. However, both the farmers who used the traditional technologies and those who used IFT had a positive gross margin. Data analysis using the probit model indicated that profitability of forage technology alone did not influence the decision to use IFT, but it did so when interacted with improved cattle breed. This implies that profitability and improved cattle breed had complementary effects on the decision to use IFT. Other factors that significantly increased the likelihood of IFT use included access to credit ($p<0.1$) and membership to farmer group ($p<0.01$). Age ($p<0.01$), educational level of the household head ($p<0.01$) and the size of land owned ($p<0.05$) significantly reduced the probability to use IFT.

Much of the difference between profitability levels for IFT users and non-users was attributed to milking herd size ($p<0.01$) and distance to the market (($p<0.05$), which benefited IFT non-users as compared to the users. stocking density ($p<0.05$) and age of the household head ($p<0.1$) favored IFT users, while membership to farmer group ($p<0.01$) and access to credit ($p<0.05$) negatively affected profitability for IFT users but had no impact on IFT non-users. These differentiating factors suggest that farmers may or may not use improved forage technologies and still be able to obtain as high profitability levels as possible. The major implications from the study findings were that use of IFT is labor saving and profitable. This suggests that policies targeting efficient dissemination of improved forage technologies are urgently needed. These should emphasize increasing credit markets in rural areas and target farmer group formation as these are major factors necessary in order to enhance the use of IFT. In addition, farmers should be availed with the necessary inputs especially forage seed. Similar studies such as this one should be carried out in other areas. Impact studies that consider long-terms impacts are also recommended.

CHAPTER ONE

INTRODUCTION

1.1 Importance of improved livestock feeding

Livestock will continue to play a significant role in the production systems of farmers in developing countries, if production is to meet the increasing demand for food associated with population growth and dietary changes (Delgado *et al.*, 1999). In developing countries, livestock production is characterized by high mortality, high susceptibility to diseases, low calving periods, late maturity, infertility and reduced reproductive parameters all of which have obvious negative impacts on household food security and income (IFAD, 2007). In addition, IFAD (2007) shows that inadequate livestock nutrition and poor feeding practices are the primary reasons for low animal production in developing countries, and a major factor affecting the development of viable livestock industries in poor countries.

Adequate quantities of high-quality feed are necessary for profitable livestock production. They help to maintain body conditions of animals, increase their resistance to disease and nutrition-related problems, and hence increase animal productivity. Improved animal feeds and feeding practices can play a significant role in the long-term alleviation of rural poverty especially in terms of their specific benefits to the rural poor such as increased livestock productivity and household food security (IFAD, 2007). In most small-scale farming systems, livestock mainly graze on native pastures and cultivated forages, including cereal and legume residues, and fodder trees and shrubs. However, the nutritive value of the natural forages varies seasonally, with significant decreases in quality and quantity during the dry season (IFAD, 2007). Smallholders therefore need to grow improved forages in order to increase animal productivity and reduce the incidence of nutritional deficiencies.

1.2 The need to improve livestock feeding

Due to the importance of livestock worldwide and the need to increase livestock productivity, research in many countries has led to development of new technologies to improve feed varieties and management practices for livestock. Most of the technologies that aim at increasing livestock productivity are in the form of improved feeding methods, such as the use of improved forage technologies. Different forage technologies have been recommended to farmers by government agencies and Non Governmental Organizations (NGOs). For instance, in recent years, more intensive grazing management has reportedly been adopted by some dairy producers in parts of the United States (Jackson-Smith *et al.*, 1996; Hanson *et al.,* 1998).

Sub-Saharan Africa, particularly in East Africa, improved livestock feeding technologies such as use of leguminous forages have been tested since the early 1900s. However, there are few cases of widespread adoption, especially in the smallholder sector (Thomas and Sumberg 1995; Sumberg 2001). Over the past 10 years, only about 200,000 farmers in Kenya, Uganda, Rwanda, and Northern Tanzania have planted fodder shrubs, mostly to feed dairy cows (Franzel and Wambugu, 2007).

In Uganda, the government and a number of NGOs have introduced intensive dairy cattle to improve nutrition, incomes and food security among resource poor households (Kabirizi *et al.*, 2007). This has been accompanied by dissemination of improved livestock feeding technologies particularly improved forages. Although these technologies have been disseminated in most districts of Uganda, Soroti district has received much attention as a result of restocking programs following insurgencies in the area from 1986 to early 1990s. In this district, improved forage technologies are being disseminated by government agencies such as National Livestock Resources Research Institute (NaLIRRI) under National Agricultural Research Organization (NARO), and NGOs such as Send a Cow, World Vision, and Soroti Catholic Diocese Integrated Development Organization (SOCADIDO). Thus, this study aimed at carrying out a comparative analysis of improved forage technologies used in Soroti district, especially those disseminated by the NaLIRRI project and some of the above mentioned NGOs, and the traditional livestock feeding methods.

1.3 Problem Statement

Livestock production is one of Uganda's major economic activities for some 80% of Ugandans, especially for the majority (84%) of the rural population that depend primarily on agriculture for their livelihood (MFPED, 2001; African Development Fund, 2002). However, Uganda's smallholder dairy cattle farming is still dependent on natural pastures, which are deficient in terms of providing adequate nutrition for the grazing cattle. The situation is worse for the Soroti district farmers who are usually faced with very long dry spells, yet dairy cattle production is one of their major sources of income.

In addition, decreasing farm size due to increasing human population and increasing competition for land between enterprises have resulted into forage[1] shortages for livestock (Winrock International, 1992). This has led to low milk yield, long calving intervals and low growth rates (Orodho, 2006). In response to land scarcity, intensive or semi-intensive dairy cattle production systems, such as stall-feeding, are increasingly becoming a major phenomenon in Uganda especially in Eastern Uganda region. This followed the cattle restocking program in this region by the Government of Uganda since 2000, through programs such as National Agricultural Research Organization (NARO) and National Agricultural Advisory Services (NAADS), to compensate households that lost their herds during the civil war of 1986 to 1990 (African Development Fund, 2002). The cattle acquired through government programs and those which the farmers acquired on their own are now an important source of milk, employment and household income for many resource poor households especially the women. The cattle restocking program mainly involved distribution of improved cows. This has led to increased necessity of high quality forages due to an increase in high genetic capacity of the stall-fed dairy cattle breeds (Kabirizi, 2006).

There are forage technologies such as grass-legume mixtures; cereal-legume intercrops; fodder trees, silage and hay making (Mpairwe, 1998; Kabirizi, 2006), whose use can help in mitigating the problem of feed shortages. Some of these technologies along with improved cows are being disseminated in Soroti district, and there are some farmers that have taken them up with the help of the mentioned NGOs in Section 1.2.

[1] Forage is the herbaceous plant material (mainly plant leaves and legumes) eaten by grazing animals (Barney, 1992). Livestock can be fed on either fresh or conserved forage. Pasture is also forage, and pasture growth can consist of grasses, legumes, shrubs or a mixture.

Wünscher *et al.* (2004), however, noted that the prerequisite for adoption would be that the new improved forage presents a solution to existing problems. This implies that increased use of improved forage technologies in areas where they are disseminated depends on how efficient these technologies are in improving feed availability, livestock productivity and profitability, compared to the old methods of livestock feeding.

There are many factors that could deter the use of improved forage technologies. Despite all other non-monetary or non-profit factors that could deter technology use, farmers in Uganda tend only to use technologies that they consider profitable (Kabirizi, 2006). While studying the adoption of land management technologies in Uganda, Sserunkuuma (2005) found that it is possible for improved technologies not to be adopted if they are of low profitability. That is, if the returns do not justify the effort required. Although there is a growing body of research work on the profitability of improved forage technologies together with improved cows in Uganda, the extant studies so far appear to concentrate on comparative analysis of different improved forage technologies while ignoring local technologies. Thus, this study sought to address the following research questions; does it pay to switch from local livestock feeding methods to the improved forage technologies? What are the key driving determinants that influence the farmer's decision to use improved forage technology? Is it the profitability of the forage technology or the type of the cattle breed or the combination of both factors?

1.4 Objectives of the Study

The major objective of this study was to characterize the smallholder dairy cattle farmers in Soroti district and determine the profitability of improved forage technologies in smallholder dairy cattle enterprises in Soroti district, Uganda. The specific objectives were:

1. To compare the profitability of dairy cattle enterprises using improved forage technologies with those using local technologies
2. To determine the factors affecting the use of improved forage technologies among smallholder dairy farmers in Soroti District
3. To identify and compare the factors responsible for profitability of dairy cattle enterprises using improved forage technologies with those using local technology

1.5 Hypotheses

1. Improved forage technologies are more profitable than the traditional method of smallholder dairy cattle feeding
2. Among other factors, profitability of a forage technology has a significant influence on whether a farmer uses an improved forage technology or not. Conversely, the use of improved forage technology substantially increases dairy profitability.
3. There exists an interactive effect between the profitability and the type of cattle breed (particularly improved cows) on use of improved forage technology.

1.6 Justification of the Study

Low productivity of smallholder dairy cattle in Uganda is partly due to the fact that livestock production is still largely based on natural pastures. The case for Soroti district is worse because of the long dry spells annually that leave access even to natural pastures difficult. There is an increasing demand for improved forage components to improve the efficiency of livestock production, as a higher proportion of land is used for cropping. The Government of Uganda through its agricultural development programs, such as Plan for Modernization of Agriculture (PMA) and National Agricultural Advisory Services (NAADS), has put in place a number of strategies. Among these is strengthening agriculture through use of low cost, high pay off inputs such as new technologies, and improving extension and research. In crop-livestock interactions, poor producers need technologies which are low cost, low risk and accessible (Cox *et al.,* 1998). Some improved forage technologies are being disseminated, but the profitability of these improved technologies versus traditional/local ones has not been established yet. There is a need to identify why some farmers switch from local methods to using improved forage technologies and others do not. This study documents and provides technical information that enables both researchers and policy makers to develop appropriate technologies and policies that are suitable for improved forage technologies adoption. This study also contributes to the much needed literature, to enable poverty alleviation project implementers (both government and NGOs) in their plan to reduce poverty in Uganda by identifying the best ways in which improved forage technology adoption can be enhanced.

CHAPTER TWO

LITERATURE REVIEW

2.1 Importance of improved forage on livestock

As farmers expand livestock production, they quickly discover the limits of naturally occurring forages and recognize the need for better feed resource (CIAT, 2006). Sown forage can increase production economically in intensive and semi-intensive production systems because such forages are of better feeding value and higher yield than natural vegetation (Mpairwe, 1998; Kabirizi, 2006). Findings from these studies indicate that improved forages have a significant effect on livestock production particularly among dairy cows.

In Asia, according to CIAT (2006), thousands of farm families in six countries have adopted new forages and management systems. The new forage technologies have significantly boosted livestock production and incomes, and reduced labor inputs, since farmers, especially women and children, spend less time tending to animals and collecting native vegetation for feed. Holman (1999) conducted a related study in Peru, Costa Rica, and Nicaragua. Results from the study indicated that the forage alternatives evaluated significantly improved the competitiveness of dual purpose farms. This was mainly through reducing the cost of producing milk between 13 and 37% with increased stocking rates and releasing up to 36% of area allocated to pastures.

In Uganda, Kabirizi *et al.* (2007) found that cows which were fed on residues from maize/lablab intercrop in addition to Napier grass during the dry season produced about 13% more milk than cows fed on sole Napier grass. In the same study, the major benefits of integrating forage legumes into the farming systems were identified as conservation of soil moisture, improvement of maize stover yield and quality, food security and improved household income. Suppression of weeds by lablab plants (reducing on labor cost) was also identified as one of the major benefits.

2.2 Evaluation of improved agricultural production technologies

Many methods have been used to evaluate improved technologies. Most of the methods aim at estimating the profits generated by the improved technologies, as compared to the conventional methods of production. Profits are widely used as the true measure of efficiency of management, and analysis of profitability is the first step to analyzing overall performance of an enterprise (Stark *et al.*, 2000; Kidoido, 2001; Pali, 2003; Odendo *et al.*, 2006). To be profitable, an enterprise should not only have high net margins per unit area, but should also have high output to input ratios, high gross margin ratios, and high returns to family labor (Wood, 1996; Glen *et al.*, 2003).

Although, gross margin is commonly used as a measure of profitability (Mburu *et al.*, 2007), it is disadvantageous in that it requires the use of all commonly shared variable cost items that are often hard obtain (Kay and Edwards, 1994). However, by using partial budgeting analysis, the problem of fixed costs and shared variable cost are minimized (Stark *et al.*, 2000). This is because as the term partial budget implies, only those changes in costs and returns that are affected by the alternative technology use are considered. The costs that do not differ across the different technologies are incurred regardless whether farmer uses the technology or not, and are therefore excluded from the calculation because they are not relevant to the particular decision (Odendo *et al.*, 2006).

Further more, the fact that input-output relationships must be appropriately defined and structured to be used when considering various alternatives, creates the need for basic budgeting techniques to organize inputs, outputs and price information. Partial budgeting is a method of organizing experimental or survey data and information about the cost and benefits from some change in the technologies being used on the farm (Ehui and Rey, 1982). It examines the costs, income and resource requirements that change with a proposed adjustment. The aim of partial budgeting is to estimate the change that will occur in farm profit or loss from some change in the farm plan (Boehlje and Eidman, 1984). It is an enterprise budgeting tool, which enables comparisons between enterprises by generating gross margins of each enterprise (Harsh *et al.*, 1981; Gittinger, 1982; CIMMYT, 1988).

While there are other types of budgeting (e.g. whole farm and enterprise budgeting), the partial budgeting procedure is the most useful tool in farming system research (Worman *et al.*, 1990), especially where there is need to capture an increase in enterprise profits brought about by the use of improved technology. Partial budget analysis, however has a limitation due to the fact that the input variables of a partial budget model are fixed averages that are crude descriptors of reality. For example, the model does not take into consideration that there may be herd level constraints that limit the feasibility of treatment (Swinkels *et al.*, 2005). The partial budget model also does not address potential interdependence of input variables. However, partial budget analysis is a relatively simple method to calculate economic effects and is useful in studies that compare relatively small changes in a system such as implementation of a test or treatment program versus no implementation of the program (Ibid).

2.3 Empirical studies on factors affecting agricultural enterprise profitability

A number of studies have estimated profitability of enterprises and the major factors that affect it. Some of these studies have indicated that that larger herd sizes, higher milk production per cow are associated with greater profitability (Hadden and Johnson 1989; McGilliard 1990, Ford and Shonkwiler 1994; Dartt *el al.*, 1999; Winsten *et al.*, 2000; Gloy *et al.*, 2002). Stocking density was also found to increase technology profitability in dairy farms (Kauffman and Tauer 1986; Hadden and Johnson 1989).

Cain *et al.* (2006) in their study done in Punjab region in Pakistan used linear programming (LP) models to assess the effect on profitability of poor livestock management in small-scale dairy farms. The results demonstrated the powerful effect on the profitability of using better, well managed dairy livestock, of increasing the uptake of simple technological improvements and of widening access to credit.

Foltz and Lang (2003), in a study conducted in Northeastern Connecticut dairy farms, found that greater grazing technology use, despite the increased productivity it results into, produces significantly lower profits. On the contrary, Gloy *et al.* (2002) found that the use of modern grazing technology increased dairy profitability among the New York farms. Where as White *et al.* (2002) in their experimental work on performance of grazing and confinement feeding systems (zero grazing) found that, although grazing cows on average produced 11.1% less milk than cows fed in confinement facilities, the feed costs associated with producing milk were lower in the grazing system. This resulted in similar profitability levels for both grazing and confinement feeding systems. Similarly, Hanson *et al.* (1998) found that there was no difference in profitability between farms that adopted grazing system and those that used zero grazing in Pennsylvania dairy farms. This indicates that the type of grazing technology ambiguously appears to be a less important determinant of dairy enterprise profitability.

Household and farm level factors have been found also to influence profitability of dairy farmers. Hanson *et al.* (1998) found that farmers using more intensive grazing practices tended to be younger and the farms had greater profitability levels. Conversely, Foltz and Lang (2003) found that age of a farmer significantly reduced dairy profitability levels. Education was found to have a significant impact on dairy profitability (Stefanides and Tauer, 1999; Foltz and Lang, 2003).

2.4 Factors influencing the decision to use improved forage technologies

According to Adesina and Baidu (1995), a given agricultural technology embodies a number of important characteristics that may influence adoption decisions. The characteristic perceptions of potential adopters were categorized by Swinkels and Franzel (1997) into the feasibility, profitability, and acceptability. The profitability evaluates whether the benefits outweigh the costs, feasibility entails the ease with which the farmer can manage the various aspects of the technology such as planting, weeding and other activities, while the acceptability encompasses the number of advantages that outweigh the disadvantages. Adesina and Zinnah (1992) added that the factors which play a key role in ascertaining farmers' decision to adopt a technology are principally categorized into the farm, farmer and technology associated attributes.

The use of agricultural production technologies such as land and livestock productivity improvement technologies is influenced by a wide range of economic, social, physical and technical aspects of farming. Numerous studies have been carried out to identify factors that influence the use (adoption) of new agricultural technologies (Feder *et al.*, 1985; Mekuria, 1995; Yirga *et al.*, 1996; Asfaw *et al.*, 1997; Tadesse, 2000; Asfaw and Admassie, 2005; Sserunkuuma, 2005; Fufa and Hassan, 2006, Doss, 2006; Salasya *et al.,* 2007). In almost all of these studies, household level characteristics such as age and education of the household head, household size, landholding size, access to credit and extension services, livestock ownership and other factors have been considered as explanatory variables.

For instance, Feder *et al.* (1985) noted lack of credit, limited access to information, aversion to risk, inadequate farm size, insufficient human capital, tenure arrangements, absence of adequate farm equipment, chaotic supply of complementary inputs and inappropriate transportation infrastructure as key constraints to rapid adoption of agricultural technologies in developing countries. In addition, Mugisha *et al.* (2004) found that lack of seed, lack of information about the technologies, costly chemical, labor intensiveness and lack of land were reasons for non-adoption. Adoption of a technology is also affected by farmers' willingness to pay for the cost associated with establishing the technology. In examining the factors that influenced participating farmers' willingness-to-pay for a tree farming fund in Bangladesh, Salam *et al.* (2005) found that farmers' willingness-to-pay was significantly affected by family income, education level and confidence that their aspired benefits would be received. This means that perception and attitudes of the farmer are important if new ideas are to be taken up. In a similar study, Haba (2004) found a correlation between farmers' willingness-to-pay for agricultural technology information delivery and some of their demographic characteristics like age and education.

However, Fufa and Hassan (2006) argue that not all factors are equally important in different areas and for farmers with different socio-economic situations. For example, Kebede *et al.* (1993) investigated the impact of social, economic and technical factors on decisions to adopt new agricultural technologies in Ethiopia. They found that peasants follow sequential adoption of technologies. They also found that the impact of indigenous production knowledge and experience on adoption decisions was positive and greater than most economic and social variables. The influence of most socioeconomic variables was greater on technologies that were proven to have a more certain outcome (e.g., fertilizer and pesticides) than on technologies which were either expensive or risky (e.g., cross-bred cows and improved seed).

Teklewold *et al.* (2006) determined the factors influencing the rate and intensity of adoption of poultry technology in East Shewa and Welayeta zones in Ethiopia. Results showed that the adoption of poultry technology was positively affected by sex of the household head, family size, availability of supplementary feed, credit and extension service and extent of expected benefit from poultry. It was negatively affected by market problem. Similarly, Salasya *et al.* (2007) found that education of a farmer, distance to the market and number of cattle owned significantly influenced the adoption of maize hybrid (WH 502) in western Kenya. A similar study done in Eastern Uganda by Mugisha *et al.* (2004) found that education, family size, association membership, extension visits, access to credit, size of cultivatable land, and household income influenced adoption of Integrated Pest Management (IPM) technologies.

Shaw (1985) examined effects of farmer characteristics and access to information on adoption of new high yielding varieties of rice in Guyana. Shaw found that the factors influencing the choice and adoption of crop varieties to include; visits to demonstration plots, planned changes with credit, years of farm experience, extension contacts, education level, age, and family size. Similar farmer characteristics appear to influence decisions involving use of livestock production technologies. McBride *et al.* (2004)

assessed the use bovine sematotropin technology, a growth hormone, among the U.S.A dairy farmers. They found that younger, more educated, more experienced milk producers were more likely to use hormone growth technology.

Labor input has been also identified as a key determinant of using agricultural technologies. Babigumira (2001) reported that labor availability was a key characteristic of farmers' decision in technology adoption. Labor demanding technologies may coincide with the seasonality of labor and in turn affect acceptance of technologies (Pali, 2003). According to Ndiaye and Sofranko (1994) and Place *et al.* (2000), the demand for labor has direct implications for the adoption of agricultural technolgies by family size, with larger families more likely to adopt.

2.5 Analytical tools used in socio-economic evaluation of agricultural technologies

The economic evaluation of agricultural technologies involves measurement of the gains of these technologies as compared to the set goals in terms of tangible values. However, the relative importance and economic values of these goals vary from farmer to farmer, depending upon the socio-economic and biophysical conditions in which they operate.

Profitability is one of the most important variables that farmers consider before taking up agricultural technologies. It was shown that profitability drives the adoption of agricultural innovations (*Current et al.,* 1995; Kabirizi, 2006). For example, farmers in

Jordan were found not to adopt some agricultural technologies such as drill machines because the associated returns did not justify the costs (Emad, 1995). Sserunkuuma (2005) also found that it is possible for improved technologies not to be adopted if they are of low profitability. Lack of profit was observed as a constraint that could be a disincentive to farmer adoption of the cut-and-carry mulch farming system developed in southwest Nigeria (Kormawa *et al.*, 1999).

Because of its importance, profitability is often used to evaluate agricultural technologies. The methods used to evaluate these technologies in terms of profitability include Gross margin analysis (Mburu *et al.*, 2007), the partial budget (Pali, 2003; Chianu et al., 2002) and return on inputs. Some studies have also used linear programming to asses the effect of using better technologies and management practices on profitability (Cain *et al.*, 2006).

Binary choice models also known as univariate dichotomous models are the most commonly used to analyze technology adoption decisions (Verbeek, 2003). These models essentially describe the probability that a technology will be adopted directly, although they are often derived from an underlying latent variable model (Salasya *et al.,* 2007). The main methods that have been used in adoption studies include the logit, the tobit, and the probit (Pindyek and Rubinfeld, 1991; Salasya *et al.,* 2007).

The logit, tobit, and probit models have the advantage of generating marginal effects of the explanatory variables on the probability of adoption. The logit model gives similar results as the probit model (Amemiya, 1991). The logit model also has the similar advantage of giving efficient and unbiased, in addition to estimating the rate of adoption. It is sometimes argued that the choice between the logit and probit model is a case of convenience. The logit and tobit models are comparable, the chief difference being that logit has slightly flatter tails; it approaches the axes more quickly than the logistic curve. The other difference is in the distribution of the error term (Maddala, 1989). However, both the logit and the probit models do not give the intensity of adoption. The tobit model accommodates the upper and lower limit of a variable, gives efficient, unbiased, and normally distributed coefficients, and can give the intensity of adoption (Ramasamy *et al.*, 1999). The tobit model is not commonly used however, because of its complexity (Ibid).

The probit model assumes an underlying normal distribution and has the advantage of giving efficient, unbiased, and normally distributed estimates (Lapar and Pandey, 1999). Specification of the probit also has advantages over logit models in small samples (Fufa and Hassan, 2006). Because this study had a small sample size, a probit model was employed to examine determinants of farmers' decision to use or not adopt improved forage technologies. Several studies on agricultural technology use (adoption) have used the probit model including Foltz and Lang (2003), Servier and Lee (2004), and Fufa and Hassan (2006).

CHAPTER THREE

METHODOLOGY

3.1 Conceptual framework for adoption and profitability of IFTs

A conceptual model for utilization of forage technologies in smallholder dairy cattle systems is presented in figure 3.1. In this study, the household was taken as the central focus for the adoption and utilization of improved forage technologies. However, it should be noted that this study was conducted for a period of one year (2007) and most of the participating farmers had been given the forage technology in the same year. Since technology adoption is considered as a long-term process, the term "use" will be used instead of "adoption".

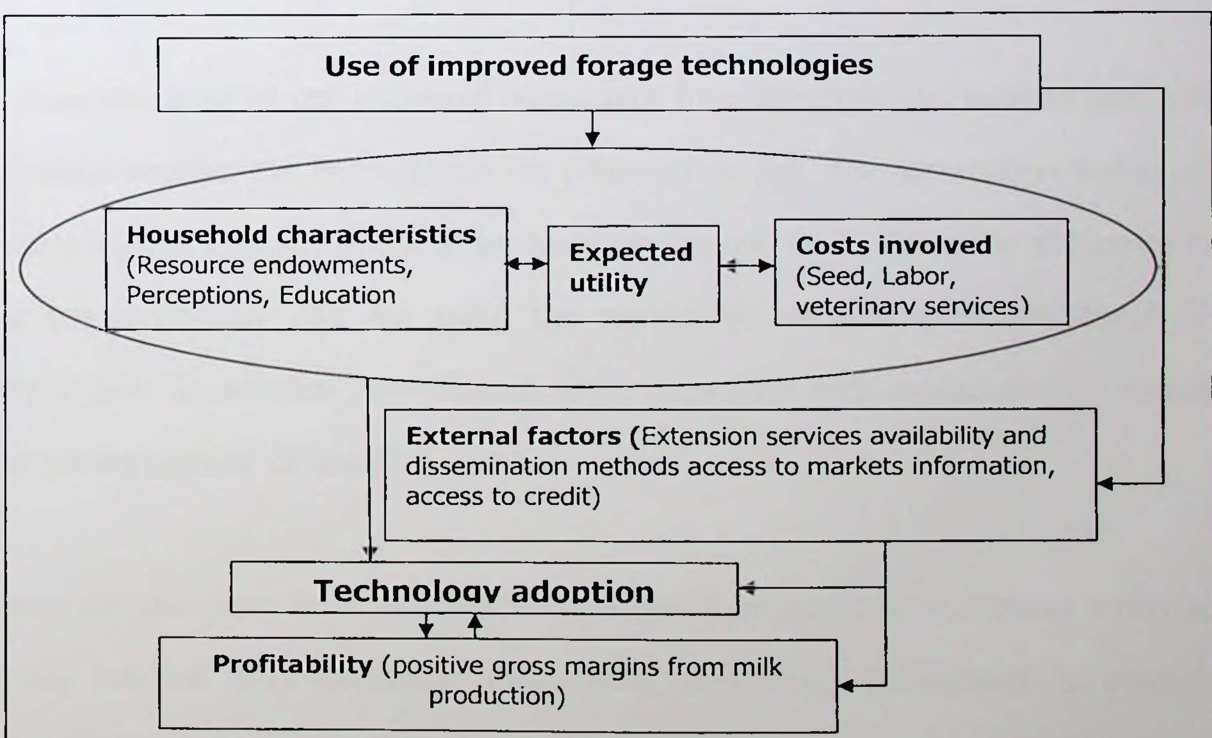

Figure 3.1. Conceptual modeling for profitability of forage technologies in smallholder dairy cattle systems

Whether a farmer uses a new technology or not depends on a number individually varying factors; the farmer expectedly ensures necessary conditions are satisfied. These conditions may include Socio-economic characteristics, household resource endowment, external factors, and expected benefits as compared to the associated costs. The farmer is expected to adopt a certain technology when these factors reach a certain threshold. This then results into profitability. Socio-economic conditions of farmers such as household characteristics (age, sex, occupation, education, household size, landholding size, livestock ownership) are the most cited factors influencing technology adoption (Feder *et al.*, 1985; Fufa and Hassan, 2006). These household factors endogenously determine the expected utility, which in turn is determined by the factor costs.

The expected utility of the individual households from the improved technologies also determines whether the technologies are taken up or not. The assumption is that an individual farmer chooses to use a particular technology when the utility difference of using the technology and not using the technology exceeds a certain threshold, normally Zero. In addition, the financial gains associated with technology use should outweigh the costs of its use (Pali, 2003).

Farmers are also likely to accept new technologies in a participatory manner when an enabling external (socio-economic, institutional, and legal) environment is present. These interventions include infrastructure development, which would facilitate advisory, credit and other services (Pali, 2003). Access to external factors such as extension services and credit along with other household characteristics enhance adoption of agricultural technologies. Participation in agricultural training and short-term extension programs, and access to credit are associated with higher uptake of land improvement technologies (Sserunkuuma, 2005).

All the above factors (Socio economic characteristics, expected utility, costs involved, and external factors) determine the level of adoption, and therefore profitability of the improved forage technology. It is hypothesized in this study that forage technology adoption together with other factors influences the profitability of the dairy cattle enterprises. In turn, profitability of an improved forage technology is also assumed to affect its technology adoption.

3.2 Description of the study area

The study was conducted in Soroti district in Eastern Uganda. This district was selected because it is one of the districts in Uganda that suffers from very long dry spells annually, that leave nearly all pastures dry leading to scarcity of livestock feeds. In addition, it is the district where many projects (National Livestock resources research institute- NaLIRRI, Send a Cow, World Vision, and Soroti Catholic Diocese Integrated Development Organization (SOCADIDO) among others) are trying out possible ways of mitigating the problem of lack of feeds for livestock in the region. It was therefore important that research be done to find out if there is enough reason for the farmers to switch from their traditional methods of livestock feeding to the ones being introduced. The region has an average rainfall ranging from 800 to 1200 mm, and the rainfall pattern is bimodal with long (March to July) and short (September to November) rainy seasons, while temperatures range from 16°C to 30°C (Yorst and Eswaran, 1990). Major economic activities for farmers in the study area are crop and livestock production. The major crops grown include sorghum, potatoes, and cassava. Dairy cattle farming systems in the district include the intensive (zero grazing), semi-intensive and extensive grazing production systems.

3.3 Description of the forage technologies and sampling procedure

The forage technologies that were evaluated in this study included the traditional forage technology (local grazing grass) and improved forage technologies. The improved technologies were introduced by The National Livestock Resources Research Institute (NaLIRRI) under the National Agricultural Research Organization (NARO) through a project "Enhancing adoption of fodder banks and forage conservation technologies in Soroti and Manafwa districts". These technologies were: 1. Maize-cowpeas intercrop, 2. Maize-lablab intercrop, 3. Sorghum-lablab intercrop, 4. Sorghum-cowpeas intercrop, 5. *Chloris gayana-Desmodium-Siratro* intercrop, 6. Elephant grass-*Desmodium intortum* mixture and 7. Elephant grass occasionally supplemented with grazing. These technologies were distributed to farmers in Soroti district with the aim of determining which of the technologies could lead to higher milk yield and hence more profits. The NaLIRRI project staff trained the selected farmers in record keeping especially on inputs use in forage and milk production.

However, the sample of farmers under NaLIRRI project was too small to allow this study to do sound econometric analysis and draw concrete conclusions. By data collection time some of the NaLIRRI project farmers had not put into use what the project had given them. This study therefore had to increase the sample as explained below. The sampling procedure was divided into two parts: one which was the NaLIRRI project sampling procedure and the other, an adjusted project sampling procedure to expand the sample size.

3.3.1 NaLIRRI project sampling procedure

A combination of purposive and random sampling procedures were used by the NaLIRRI project staff. Two sub-counties were purposively chosen from Soroti district where intensive dairy cattle production was a priority enterprise. The chosen sub-counties were Gweri and Arapai. From each of the selected sub-counties, one village was also purposively selected. The selection of farmers at the village level accounted for gender and age groups; where all the groups got equal representation – men, women, youth and the elderly. A list of improved dairy cattle farmers having 1-3 improved cattle was compiled (this was one of the basic requirements of the NaLIRRI project). Forty[2] households with improved dairy cattle were randomly selected from the list of the dairy cattle farmers in the two sub-counties (20 from Arapai and 20 from Gweri). It this group that the study initially intended to focus on. The selected farmers had to meet the following conditions; have at least one improved cow and at least a half an acre of land available for forage planting. Each of the participating livestock farmers was given

[2] During data collection, it was found that although 40 farmers had been given improved forage technologies by the NaLIRRI project, only 31 had planted the materials they were given.

inputs by the NaLRRI project. These comprised of grass and a legume planting materials per farmer. The grass-legume crop combination constituted an improved forage technology.

Given that NaLRRI project only sampled farmers with at least one improved cow, a comparative analysis between farmers using traditional and improved forage technologies would not be possible. Below is the adjusted NaLIRRI project sampling procedure.

3.3.2 Adjusted NaLIRRI project sampling procedure

In the study area there were some NGOs such as Send a Cow, World Vision, and Soroti Catholic Diocese Integrated Development Organization (SOCADIDO) promoting improved forage technologies which were similar to those of NaLIRRI project. This provided a basis for expanding the sample size without biasing the NaLIRRI project selection criteria. In each of the selected villages by the NaLIRRI project, an additional six farmers were randomly selected. The additional sample selection was obtained from the list of farmers using improved forage technologies that were being promoted by the NGOs in the area. Six[3] farmers from each were chosen because of difficulty in accessing farmers using the same forage technologies as those of the NaLIRRI project. A total of 43 farmers using improved forage technologies (31 farmers from NaLIRRI project plus 12 farmers from other NGOs) participated in this study. In addition, in the same areas

[3] Six farmers from each village were chosen because of the difficulty in accessing farmers using the same forage technologies as those of the NaLIRRI project. Unavailability of such farmers limited the number of additional respondents.

where the NaLIRRI project was operating, 78 farmers who were not using any of the improved forage technologies but had milking cows (local or improved) were randomly selected. This number was also arrived at by the conditions in the field where all willing participants reached were included in the study. These were considered as farmers using traditional technology and were used for comparison purposes.

Data used in this study were collected in May 2008 using a structured and pre-tested questionnaire (Appendix 4). The questionnaire was pre-tested on both the farmers using improved forage and those using traditional technologies. The data collected included: technology disseminated and its uptake, quantity and cost of inputs allocated to different forage and milk production, marketing and transaction costs, and milk consumption. The data were entered into Statistical Program for Social Scientists (SPSS) and analyzed using STATA 10.

3.4 Analytical Methods

The analytical methods that were used to achieve the objectives of this study included; partial budget analysis, the probit model, and the linear regression model.

3.4.1 Partial budget analysis

Testing of the null hypothesis that improved forage technologies are more profitable than the local technology was done through a partial budget economic analysis that calculated gross margin over improved forage expense. Gross Margin (GM) per unit is commonly defined as the difference between Gross Return (GR) and Total Variable Cost (TVC) (Kay and Edwards, 1994). Gross Return is calculated by multiplying yield by the price of product, whereas Total Variable Cost is the summation of all variable costs involved in production. Gross margin analysis is a commonly used approach in agricultural economics when examining small adjustments in production technologies (Stark *et al.*, 2000). Gross margin as a tool of analysis is necessary where partial budgeting analysis excludes fixed costs so as to suit partial budgeting principles that have also long been utilized in production economics (Stark *et al.*, 2000; Omadachi *et al.*, 2007).

The partial budget (Swinkels *et al.*, 2005; Castle *et al.*, 1987; Boehlje and Eidman, 1984; Ehui and Rey, 1982) captures the increase in enterprise profits that was brought about only by the use of improved forage technology. The partial budgeting model is based on the principle that a small change in the management and organization of a farm business will have one or more of the following effects: eliminate or reduce some costs; eliminate or reduce some returns; cause additional costs to be incurred; cause additional returns to be received. These four increases or decreases in revenues and/or expenses make up the structure of a partial budget model. The net effect is obtained as the sum of positive economic effects (revenue) minus the sum of negative economic effects (costs) (Boehlje and Eidman, 1984; Hady *et al.,* 1994). In a partial budgeting model, economic effects are calculated as total revenues weighed against total costs.

$$\Delta GM_i = \Delta TR_i - \Delta TVC_i \qquad (1)$$

Where

ΔGM_i = change in gross margin (UShs. $Cow^{-1}Month^{-1}$)

ΔTR_i = change in average total returns (UShs. $Cow^{-1}Month^{-1}$)

ΔTVC_i = variable cost (UShs. $Cow^{-1}Month^{-1}$)

i = Forage technology (improved or traditional)

A positive (negative) difference indicates that the margin obtained as a result of the use of alternative/ new forage technology exceeds (is less than) the gross margin obtained from the dairy enterprise when using the prior/old forage technology. Additional income was taken as the additional revenue from milk sold and consumed. Reduced expenses were taken as the reduced labor costs in terms of time spent grazing and reduced costs of buying feeds/forages, or looking for wild feeds for the animal. Additional expenses included labour (family and hired), cost of veterinary services, and cost of feed (grown at home, but assuming it was bought from else where, how much it would cost).

3.4.2 The probit model

To determine the factors affecting the use of improved forage technologies among the small holder dairy farmers and test the hypothesis that profitability of a forage technology has a significant influence on whether a farmer uses an improved forage technology or not, a probit model was used. The same probit model was used to test the hypothesis that there exists an interaction effect between the profitability and the type of cattle breed (particularly improved cattle) on use of improved forage technology.

It is assumed that the type of cattle breed owned and profitability appear to have an interactive effect on use of improved forage technologies (hereafter referred to as IFT). That is, the type of breed and profitability are said to interact in determining whether the farmer uses IFT or not, if the effect of cattle breed on use of IFT depends on the level of forage profitability (which implies, symmetrically, that the effect of profitability on use of IFT depends on the type of the breed). Because of this interactive effect, it was plausible enough to test for the presence of interaction by including the product of type of breed owned and the profitability as an additional variable. This is based on the assumption that such effects are multiplicative and are determined by adding a term equal to the product of the two variables as an independent variable (Jaccard *et al.*, 1990).

Since it appears that the use of forage technology is jointly determined with the profitability of that technology, there is an endogeneity problem. Thus, the probit model used follows Grogger (1990) and Wooldridge (2002) as shown below:

$$w_i^* = \alpha\pi_i + \theta B_i\pi_i + \beta X_i + u_1 \qquad (2a)$$

$$\pi_i = \gamma X_i + \alpha Z_i + u_2 \qquad (2b)$$

$$w_i = \begin{cases} 1, & w_i^* > 0 \\ 0, & otherwise, \end{cases} \qquad (2c)$$

Where u_1 and u_2 are error terms with mean zero, bivariate distribution and independent of X_i; w_i^* is a latent variable for farmer i; θ is the parameter to determine whether there is an interaction effect between the type of the cattle breed (B_i) and profitability

(π_i). Equation (2b) is a reduced form for π_i, which is endogenous profitability variable if u_1 and u_2 are correlated. If u_1 and u_2 are independent, there is endogeneity problem. The test for endogeneity was done as shown in Appendix 2. X_i is the vector of exogenous regressors, while α, β and γ are respective unknown parameters. Z_i is the vector of explanatory variables that directly affect the dairy profitability but do not directly affect the use of improved forage technologies such as the means of transporting milk to the market place and access to veterinary services. Equation (2c) assumes that there is a threshold level of the latent variable, such that if w_i^* exceeds zero, the farmer's decision would be to use the improved forage technology $(w_i = 1)$, otherwise the farmer would not $(w_i = 0)$.

Since farmers themselves decide whether to use forage technologies, this form of decision making is by self-selection (Wooldridge, 2002). This means that a farmer who chooses to use improved forage technology will likely have relatively high milk output and profit per cow. That is, the use of improved forage technologies and profitability of milk production are jointly determined. Thus, it follows that the profitability variable cannot be treated as an exogenous variable. If equation (2) is estimated by ordinary probit, inconsistent estimates of the parameters will result. Correction for this self-selection bias is usually done by using instrumental estimation (Grogger, 1990; Wooldridge, 2002). The instrumental variable probit model estimated was specified as;

$$w_i = \beta_0 + \beta_1 X_1 + \ldots + \beta_T X_T + \theta B_i(\pi_i = \gamma_1 X_1 + \ldots + \gamma_T X_T + \alpha Z_i) + \varepsilon_i \quad (3)$$

Where X_1 ... X_T are some of explanatory variables responsible for explaining the variation in of use of forage technologies. Z_i is the vector of explanatory variables that directly affect the dairy profitability but do not directly affect the use of improved forage technologies such as the means of transporting milk to the market place and access to veterinary services. ε_i is the error term. Other terms are as defined earlier.

The factors expected to affect adoption of improved forage technologies included size of land owned, membership to groups, frequency of visits by trained personnel, age of household head, education of household head (years in school), number of dependants in a household, number of cows owned, labor cost in livestock production per season, distance to the market, access to any form of credit, and experience in livestock production.

3.4.3 The linear regression model

The NaLIRRI project conducted an experiment where some farmers were given certain forage technologies. The aim was to determine the impact of these technologies on milk production before and after technology up-take. Under this experiment, the proposed analytical tool was the counterfactual framework (Imbens and Angrist, 1994; Heckman, 1997; Wooldridge, 2002; 2007). The counterfactual framework allows for defining the treatment effect of interest on the outcome, where each farmer has an outcome (dairy profitability level) with and without treatment (up-take of improved forage technology). However, this framework was opted out for linear regression for three reasons: One, the project time frame was too short to allow for adequate time for experimentation. That is, in a space of one year, the project's efforts to cause considerable impact on the dairy farmers' up-take of technologies and hence dairy production do not warrant the use of counterfactual framework. Two, the NaLIRRI project baseline survey did not provide data on dairy profitability levels in the "before-up-take" period. This would provide a comparative analytical benchmark against the "after-up-take" period. Three, even if one would use the recall method to collect data in the "before-up-take" period (the researcher tried this method but it did not yield realistic data), the sample size was too small to allow in-depth counterfactual analysis. Thus, the following approach was used.

The Gross Margins obtained from objective one were used as the dependent variable to identify and compare the factors responsible for profitability of dairy cattle enterprises using improved forage technologies and those using the local feeding methods. The modeling of farmers' dairy profitability is somewhat similar to the preceding modeling of use of improved forage technologies. The theoretical frame is built on notion that the farmers' use of improved forage technology is driven by the expected profitability from the technology. In turn, the profitability of the forage technology is assumed to be dependent on that technology's use level. This means that the adoption of the technology is endogenous in the profitability model. The linear regression equation estimated was;

$$\pi_i = \gamma X_i + \delta w_i + e_i \qquad (4)$$

Where π_i is the profit variable for farmer *i*, X_i is a vector of explanatory variables, w_i is a dummy variable for use of improved forage technology use ($w_i = 1$, if technology is used, 0 otherwise), and e_i is a random disturbance assumed to be normally distributed.

If δ is to measure the impact of use of forage technology and test the hypothesis that the use of improved forage technology substantially increases dairy profitability, farmers should be randomly assigned whether or not forage technology is used (Wooldridge, 2002). Similar to estimation in equation (2), there is a problem of self selection. This is because farmers themselves decide whether to use forage technology or not. As may be expected, the typical farmer who chooses to use forage technology will likely have relatively high milk output and hence higher profitability levels even if forage technology is not used. This implies that the dummy variable w_i cannot be treated as an exogenous variable. Otherwise, estimating equation (4) by ordinary least squares (OLS) yields inconsistent estimates of the parameters. Thus, from equation (2) and (4), the expected profit, π_i can be obtained by following Wooldridge (2002) and Greene (2003).

$$E[\pi_i] = E[\pi_i | w_i = 1] * prob(w_i = 1) + E[\pi_i | w_i = 0] * prob(w_i = 0) \quad (5a)$$

$$= \gamma X_i + \delta\Phi(\beta X_i) \quad (5b)$$

Where Φ is cumulative standard normal function. Thus, $\Phi(X_i\beta)$ serves as the instrumental variable for π_i in equation (4) to avoid the biased estimators. Using this framework, the parameters of both the profitability model and the use of improved forage technology model are obtained. In order for $\Phi(X_i\beta)$ to serve as a valid instrument, the exclusion restriction is needed to identify the parameters (Wooldridge, 2002); the factors that influence the decision to use the improved forage technology, but do not affect dairy profitability directly. The training or extension on improved forage technologies, method of disseminating the technologies, and forage seed availability were the factors used to satisfy exclusion restriction.

3.4.3.1 Empirical model specification

The empirical model was estimated in a two-stage procedure: First, by estimating the binary response equation (2) by maximum likelihood to obtain fitted probabilities $\Phi(X_i\beta)$. Second, by estimating

$$\pi_i = \gamma_0 + \gamma X_i + \delta w_i + e_i \tag{6}$$

by IV using instruments $\Phi(X_i\beta)$ and X, where γ_0 = constant. The final empirical estimated was

$$GM = \gamma_0 + \gamma_1 X_1 + \gamma_2 X_2 + \gamma_3 X_3 + \gamma_4 X_4 + \gamma_5 X_5 + ... + \gamma_{12} X_{12} + \Phi(\beta X_i) + e_i \tag{7}$$

Where GM= gross margin, other terms are as defined above (Previous equations). The factors expected to affect profitability of improved forage technologies and their expected signs are shown in Table 3.1.

Table 3.1: Factors expected to affect profitability of IFT

Variable	Expected sign
Use of the improved forage technology	+
X_1 Total land owned (Hectares)	+
X_2 Distance to markets (Km)	+
X_3 Number of visits by extension agents per month	+
X_4 Experience in livestock production (years)	+
X_5 Milking herd size	+
X_6 Age of the household head	+/-
X_7 Age of the household head squared (years)	+/-
X_8 Education of the household head (Years spent in school)	+
X_9 Dummy for Access to credit (whether the farmer has ever received credit (1 Yes, 0 No)	+
X_{10} Stocking density (number of cows per unit grazing area)	+
X_{11} Number of dependants in a household	-
X_{12} Membership to any farmers' group =1, 0 otherwise	+
ε Error term	

3.4.3.2 Empirical estimation procedure and hypothesis testing

The estimation of the models outlined above followed a series of regression diagnostics. The variables used in the regressions were first checked for normality and symmetry using Exploratory Data Analysis (EDA). This was done by checking the coefficient of kurtosis and skewness. Regression diagnostics included tests for multicollinearity, heteroscedasticity and self-selection bias. Multicollinearity was tested using variance inflation factor (VIF) and the correlation matrix. Heteroscedasticity was checked using

Breusch-Pagan/Cook-Weisberg tests (Wooldridge, 2003; Greene, 2003). The leverage-versus-squared-residual plot was used to identify regression outliers and leverage points.

Self-selection bias was checked by testing for exogeneity of Gross Margin (GM) in the IFT model following a procedure in Wooldridge (2002), page 474. Where the null hypothesis that Gross margin is exogenous in the IFT model is H_0: $\phi = 0$. If $\phi \neq 0$, then usual probit standard errors and test statistics are not strictly valid. ϕ is the coefficient on the residuals generated from the GM model (Appendix 2).

To test whether there exists an interactive effect between the profitability and the type of cattle breed in the IFT model, three tests were done to confirm the results and check their consistency (Appendices 1 and 2). First, the Likelihood Ratio (LR) test was done to evaluate the difference between the IFT model without interaction terms and the model with interaction terms of cattle breed and the GM. Four models were run. The first model was run with all variables considered in this study except for interaction terms. This was defined as a reference model. The second model was run with all variables in the reference model plus the interaction terms of: GM and number of local cows; GM and number of local cows squared; GM and number of improved cows; and GM and number of improved cows squared. The third model was estimated with all variables in the reference model plus the interaction terms of: GM and number of improved cows; and GM and number of improved cows squared. And the fourth model was run all variables in the reference model plus the interaction terms of: GM and number of local cows; and GM and number of local cows squared. The LR test null hypothesis is that adding interaction terms improves the regression power of the reference model (Wooldridge, 2002).

The second test was the Lagrange Multiplier (LM) test. The LM test almost does a similar job as the LR test. The LM test is done by leaving out the predictor variables in question to observe whether the omitted variables reduce model fit significantly. The third and the most popular test that has been widely used (Allison, 1977; Jaccard *et al.*, 1990; Nagler, 1991; Cleary and Kessler, 1982; Braumoeller, 2004; Brambor *et al.*, 2006) to test existence of interaction effect is the Wald test. This is done by testing the joint significance of the variables of interest in the model. The null hypothesis is that the interaction terms are jointly significant in explaining variation in the IFT model.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents and discusses the findings of this study. The discussion focused on the farmers' characteristics and their perceptions about the use of forage technologies. Farmers who were given improved forage technologies by NaLIRRI project or those who were using forage technologies from other NGOs are referred to as users of improved forage technology (IFT). Farmers who were not given improved forage technologies and were using local feeding methods are referred to as non-users of improved forage technology. This chapter also compares the profitability of using improved and local forage technologies, the factors that affect use of the improved forage technologies, and those that affect profitability of those technologies.

4.1 Characteristics of farmers in Soroti district

The socio-economic characteristics considered in this study were age of the farmer, sex of the farmer, education of the household head, number of dependants per household, and decision making on technology use. The results are shown in table 4.1.

Results showed that the farmers that participated in the study were of productive age, about 45 years on average. The majority of these livestock farmers (73.6%) were male. Farmers who used improved forage technology had spent more years in school (7.5 years) than their counterparts, who on average had 6.8 years in school. This could mean that the more years the farmers spend in school the higher the chances of using improved forage technologies. This is because the more educated farmers easily understand better the potential benefits than their less educated counterparts. This is in line with earlier studies which noted that education increases the ability to acquire information (Alesina and La Ferrara, 2002) and hence enhances adoption of agricultural technologies (Asfaw and Admassie, 2004).

Table 4.1: Characteristics of users and non-users of improved forage technology (IFT)

Variable	Entire Sample (n=121)	Users of IFT (n=43)	Non-users of IFT (n=78)	t-value/ Chi-Square value
Age of the farmer	44.6 (11.9)	45.0 (12.0)	44.3 (11.8)	-0.292
Percentage of male farmers in the sample	73.6	72.1	74.4	0.073
Education of household head (years in school)	6.8 (3.3)	7.5 (3.1)	6.4 (3.3)	-1.720*
Average number of dependants	6.3 (3.2) (n=120)	6.6 (3.4) (n=43)	6.1 (3.0) (n=77)	-0.752
% households heads with position of responsibility in community	45.4 n=119	58.1 (n=43)	38.2 (n=76)	4.424**
Major decision maker in use of improved forage technology	**n=92**	**n=29**	**n=63**	**Chi square value**
% reporting man	48.9	51.7	47.6	0.429
% reporting woman	9.8	6.9	11.1	
% reporting both man and woman	41.3	41.4	41.3	

Figures in parentheses are standard deviations. ** and * are significant levels at 5% and 10% respectively. Where a different **n** figure is given was due to missing data.

Although results show that the use of forage technology is not linked with who makes the decision within a household, having a responsibility in community plays an important role. There was a significant difference ($p<0.05$) between the users of the improved forage technology and the non-users with regard to holding positions of responsibility in the community. While only 38.2% of the non-user farmers held such positions in the community, 58.1% of the users of improved forage technologies had positions of responsibility. Persons with positions of responsibility in the community such as local council heads, community opinion leaders and church leaders are normally approached first when new opportunities/new technologies are brought into their areas. This means that most of the time, they are the first beneficiaries before the rest of the community.

4.2 Experience of IFT users and source of improved forage technologies

Table 4.2 shows results of farmers' experience and source of improved forage technologies. The results show that the farmers had fairy good experience of about 4 years in using improved forage technologies. The majority (52%) of them obtained the technologies from National Livestock Resources Research Institute (NaLIRRI), followed by other NGOs (28%) such as Send a Cow, World Vision, and SOCADIDO. A small percentage of farmers using IFT (20%) reported having received forage technologies from fellow farmers.

The most commonly used method of dissemination of the improved forage technologies was found to be through expert visits to farmers' groups (53.2%). This was followed by farmer-to-farmer delivery (29%), radio/television (10%) and expert visits to individual farmers (8%). However, these results appear to contradict a somewhat similar study conducted in Rwanda (Haba, 2004). Haba found that farmers in the Abahuzamugambi Coffee Growers Cooperative preferred mostly the farmer-to-farmer delivery mode of technology transfer to expert visits, print, radio, and television.

On the other hand, the most popular method used in IFT dissemination for this study may not be necessarily what the farmers preferred. The question would be on whether they had a choice in the matter.

Table 4.2: Experience of IFT users and source of improved forage technologies

Variable	mean/percent
Average years of forage technology use (n=43)	4.3 (2.7)
% reporting sources of forage technology (n=86)	**Percent**
National Agricultural Research Organization (NARO)	52.3
Other organizations	27.9
Fellow farmers	19.8
% reporting methods of dissemination (n=62)	**Percent**
Expert visits to farmers' groups	53.2
Farmer to farmer delivery	29.0
Expert visits to individuals	8.1
Radio/Television	9.7

4.3 Resource endowment of cattle farmers in Soroti District

Whether an improved forage technology is taken up or not depends on whether the farmer has enough resources to use. These may include land on which to plant the forages, human capital particularly experience and the number of cattle that may justify the allocation of land to growing forages other than other crops. For instance, adoption studies have used the proportion of land allocated to new technologies as the measure of adoption (Nkonya *et al.*, 1998; Kotu *et al.*, 2000; Mussei *et al.*, 2001), while others have used "histories of technology use" (experience – human capital) as the measure of adoption (Doss, 2006). Table 4.3 shows comparative results of these resources between the users and non-users of improved forage technology.

Table 4.3: Resource access and utilization by livestock farmers in Soroti district

Variable	Entire Sample (n=121)	Users of IFT (n=43)	Non-users of IFT (n=78)	t-value/ Chi-Square value
Average land owned (hectares)	16.2 (15.8)	18.1 (20.5)	15.2 (12.6)	-0.947
Average land rented (hectares)	0.7 (2.0)	0.5 (1.4)	0.8 (2.3)	0.705
Average land borrowed (hectares)	0.7 (2.4)	0.8 (3.5)	0.6 (1.6)	-0.494
Proportion of land allocated to cattle	0.23 (0.1)	0.24 (0.2)	0.23 (0.1)	-0.216
% reporting modes of land acquisition				
Percentage inherited	83.5	74.4	88.5	
Percentage purchased	14.9	23.3	10.3	3.989
Percentage given as a gift	1.7	2.3	1.3	
Cattle ownership				
Average number of local cows owned	7.4 (8.6)	7.2 (10.4)	7.6 (7.5)	0.257
Average number of improved cows owned	0.9 (1.4)	1.9 (1.4)	0.3 (1.0)	-7.421***
Experience in livestock production (years)	9.7 (9.9)	10.6 (10.9)	9.2 (9.3)	-0.718

*** implies significant level at 1%. Figures in parentheses are standard deviations

Generally, livestock farmers that participated in the study had reasonably sizable amount of land owned, 16.2 hectares on average that were mainly acquired through inheritance (83.5%). Farmers seemed to allocate a small proportion (23%) of their total land to cattle keeping. This cut across the two categories – users and non-users of improved forage technologies. For both categories, there was no significant difference in amount of land owned, rented-in and borrowed-in and so was the proportion of land allocated to livestock keeping. This implies that neither users nor non-users of IFT had a profitability advantage over the competing crop enterprises.

The similar size of land allocated to cattle grazing between users and non users of IFT may also be attributed to the number of cows owned. Results showed that both users and non-users of IFT owned about the same number of local cows, although the users had significantly ($P<0.01$) more improved cows than their counterparts. Most of the farmers in Soroti district who started using improved forage technologies were mainly applying them on improved cows, especially the zero grazing cows in order to maximize their potential. This may also offer an explanation as to why there was no variation in the size of land allocated to cattle keeping. This implies that the size of land allocated to forage growing was marginal, since the forage area was considered as part of pasture land.

Similarly, there was no substantial difference in the years of experience in livestock production between users and non-users of IFT, although the former had two years more in experience than the latter. That is, the users had about 11 years of experience in livestock production compared to 9 years for non-users.

4.4 Comparison of production costs and milk production between users and non-users of IFT

This study focused on comparing farmers using improved forage technologies (IFT) and those using the local methods of livestock feeding. The observations on the seven improved forage technologies mentioned in section 3.3 were pooled and collapsed to constitute a general reference as "use of improved forage technologies". This was done due to limited number of observations per technology. The local forage technology in this study was taken to refer to use of local grazing grass.

4.4.1 Production costs

The costs of production for the users and non-users of IFT were computed per cow per season. Seasonal analysis was preferred to daily or even monthly because the amount of input use may vary from month to month or daily. This variation is unlikely to be the same for all households. For instance, veterinary expenses may vary greatly from month to month for a given farmer, but can be better captured seasonally. The season was taken to be six months. The major costs considered in this study included labor costs, veterinary expenses, spraying costs, and the costs of forage seeds for those farmers who purchased seed. A part from labor, the number of observations on other input costs was, in some cases, very small. This led to combining all other inputs except for labor and defined them as "other input costs".

Table 4.4: Production costs between users and non-users of IFT

Variable	Non-users of IFT (n=73)	Users of IFT (n=42)	Mean Difference	t-value
Labor costs per cow per season (Ug. Shs)	79,898.7 (59,313.5)	54,544.3 (67,570.6)	25,354.4	2.097**
Other input costs per cow per season (Ug.Shs)	6,520.5 (11,477.3)	4,672.7 (7,994.7)	1,847.8	0.922
Total production costs per cow per season (Ug. Shs)	86,419.2 (64,588.8)	59,217.1 (71,575.4)	27,202.1	2.090**

Figures in parentheses are standard deviation. ** is significance level at 5%.

Results in Table 4.4 indicate that the farmers using the improved forages had significantly lower ($p<0.05$) production costs than the non-users. The production costs of the users of the improved forage technologies were about 1.5 times less than those of the non-users. This difference was largely due to labor costs. Non-users of IFT incurred substantially higher labor costs than their counterparts. Farmers using IFT incur lower labor costs in cutting and carrying forages to the zero grazing stalls than for grazing animals for a full day throughout the month. The traditional method of livestock feeding involves long hours of grazing and search for pastures that could be costly in terms of the costs per hour spent working compared to the costs of cutting and carrying the forages. Other input costs were also higher for the non-users of IFTs. This could be because the farmers who got the improved forage technologies were also the same farmers in groups that could access training on better animal husbandry practices. Better practices mean that the livestock are treated well, fed well, and are kept in better conditions which can lower their incidences of ill health and need for the veterinary services. This lowers the costs of veterinary services and other costs that would have resulted from poor management practices.

4.4.2 Milk production, consumption and sales

The descriptive analysis of milk production was done at two levels – milk production per day and milk production per cow per season. Because at the time of the survey, some farmers still had one or more milking cows, while others had one or more milking cows in the previous six months. Table 4.5 shows results of total milk daily production, disposition and milk production per cow per season. Results show that farmers using IFT produced more milk per day than non-users by a significant margin ($p<0.01$) of 3.5 litres, (10.2 litres to 6.6 litres). Similarly, milk production per cow per season was substantially higher ($p<0.01$) for farmers using IFT than non-users. The higher production level of farmers using IFT may be attributed to high nutritive value of forages as compared to natural pastures that may be of low nutritive value.

Table 4.5: Milk production, consumption and sales between users and non-users of IFT

Variable	Non-users of IFT (n=69)	Users of IFT (n=41)	Mean Difference	t-value
Milk production per day (litres)	6.6 (6.0)	10.2 (7.7)	-3.5	-2.692***
Proportion of milk consumed per day	0.44 (0.34)	0.30 (0.21)	0.13	2.256**
Proportion of milk sold per day	0.56 (0.34)	0.69 (0.21)	-0.13	-2.224**
Average and median price of a litre of milk	381.5 (106.4) {400}	385 (128.2) {400}	-3.5	-0.143
Milk yield (litres per cow per season)	349.0 (220.8) (n=73)	846.9 (613.9) (n=42)	-497.9	-6.276***

Figures in parentheses are standard deviation and those in braces are medians. *** and ** are significance levels at 1% and 5% respectively.

From results in Tables 4.4 and 4.5, farmers using IFT had productivity advantages over those not using IFT. That is, the production costs per litre per season of IFT users were as low as Ushs. 70, more than three times less than the costs incurred by the IFT non-users (Ushs. 248 per litre per season). This finding conforms to earlier work of Gloy *et al.* (2002). Using simple comparison, Gloy *et al.* (2002) found that the rate of returns on inputs for grazing farms was largely lower than that of non-grazing farms in New York dairy farms. This implies that amount of milk produced per cow largely depends on the quality of feeds. The natural grasses/forages in Soroti are usually over grown, dry most of the year and scattered all over the area, which may explain the low nutritive value and high cost of grazing and hence low milk production.

4.5 Profitability of cattle enterprises using and not using IFT

A partial budget for the farmers who were using the improved forage technologies and those who were using the local technology is presented in Table 4.6. Total revenue per cow per season was computed as a product of milk yield and a median price of Ushs. 400 per litre. The market price was used to make the computations. The median price was preferred to the mean price because median is more resistant to outliers.

Table 4.6: Partial budget results for milk production in Soroti district

Variables	Entire sample (n=115)	Non-users of IFT (n=73)	Users of IFT (n=42)	t-value
1. Credits (Revenues)				
Average milk production per cow per season	530.8 (473.6)	349 (220.8)	846.9 (846.9)	-6.276***
Total revenue per cow per season (UShs)	**212,328.4** (189,436)	**139,596.9** (88,303.3)	**3,38742.9** (245,557.5)	**-6.276*** **
2. Debits (variable costs)				
Labor costs per cow per season	70,638.9 (63,359.1)	79,898.7 (59,313.5)	54,544.3 (67,570.6)	2.097**
Other input costs per season	5,845.7 (10,343.2)	6,520.5 (11,477.3)	4,672.7 (7,994.7)	0.922
Total cost per cow per season (UgShs)	**76,484.6** (68,193.3)	**86,419.2** (64,588.8)	**59,217.1** (71,575.4)	**2.090** **
3. Gross margin per cow per season	**135,843.9** (209,917.3)	**53,177.6** (112,896.8)	**279,525.7** (258,505.1)	**-6.496*** **
Return on inputs[a]	**6.3 (14.7)**	**3.1 (6.2)**	**12.3 (22.4)[1]**	**-3.288*** **

[a]Return on inputs was only computed for 39 farmers because data was not available for three farmers. Figures in parentheses are standard deviations. *** and ** are significance levels at 1% and 5% respectively.

Results show that using improved forage technology was considerably more profitable, than using local methods of feeding. Farmers using IFT generated a five-times bigger margin per cow per season than those not using IFT ($p<0.01$). This is consistent with the hypothesis that improved forage technologies are more profitable than the local feeding methods of smallholder dairy cattle production. However, milk production by both the farmers using IFT and non-users was profitable in absolute terms. This implies that despite the type of cattle feeding technology used – improved or local, it is still profitable to produce milk in Soroti district.

Further analysis was done to ascertain whether the hypothesis holds by using return on inputs. Return on inputs is an indicator of how profitable a technology is relative to its total assets. It gives an idea as to how efficient management is at using its inputs to generate profits. Farmers using local grazing methods had an average return on inputs of 3.1%, a profitability level that is competitive with "safe" input investments, but not as competitive as 12.3% for farmers using IFT. The low return on inputs for non-users of IFT may be due high labor cost requirements as indicated earlier in Section 4.4.1. It also may have been due to unobservable management factors such as the ability of the farmer to make input allocation decisions. The significantly ($p<0.01$) higher return on inputs attained by farmers using IFT may be possibly related to advantages of commercialized production, higher per cow milk production levels and greater labor efficiency.

4.6 Factors affecting adoption of improved forage technologies

The binary probit model was estimated to explain the behavior of forage technology usage of livestock farmers in Soroti District. To test the hypothesis that profitability of a forage technology has a significant influence on whether a farmer uses an IFT or not (first part of hypothesis two), and the hypothesis that there exists an interactive effect between the profitability and the type of cattle breed in the IFT model (hypothesis three), several tests preceded the analysis as aforementioned in Chapter 3. The exogeneity test results in Appendix 2 indicated that profitability is exogenous in the IFT model. This means that the estimates in the IFT model with profitability (Gross margin) as explanatory variable are consistent and efficient. Multicollinearity was tested using correlation matrix and the model passed this test too. Potential heteroscedasticity was fixed by using robust standard errors.

Results from the Likelihood Ratio (LR) test which was used to test the hypothesis that there exists an interactive effect between profitability and the type of cattle breed in the IFT model are presented in appendix 3. The results showed that adding all the four interaction terms: GM and number of local cows; GM and number of local cows squared; GM and number of improved cows; and GM and number of improved cows squared, to the reference Model I (which had no interaction terms) resulted in a statistically significant improvement in regression fit of Model II. However, this was not as significant as when GM and number of improved cows; and GM and number of improved cows squared were added in Model III. The LR test rejected the null hypothesis that adding interaction terms of GM and number of local cows; and GM and number of local cows squared to Model I as predictors improves the model fit.

The Lagrange Multiplier (LM) test results indicated that the inclusion of the interaction terms of GM and number of local cows, and GM and number of local cows squared weakly reduced the significance of the model fit compared to a significant reduction ($p<0.01$) when the interaction terms of GM and number of improved cows, and GM and number of improved cows squared are omitted in Model I.

From the Wald test results, the null hypotheses that including interaction terms of GM and number of local cows, GM and number of local cows squared and joint inclusion of all the four interaction terms improved model fit were all rejected at highly unacceptable levels of significance, 60% and 20 % levels respectively. However, the inclusion of interaction terms of GM and number of improved cows, and GM and number of improved cows squared increased the model fit significantly ($P<0.05$). This was consistent with the hypothesis that there exists an interaction effect between the improved cattle breed and the profitability of the forage technology on use of IFT. Put differently, rearing improved cattle breeds together with increased profitability of forage technology significantly influence the decision to use improved forage technology. Thus, the rest of the discussion focuses on Model III in Table 4.7.

Table 4.7: Determinants of use of improved forage technologies

Dependent – use of improved forage technologies =1, 0 otherwise	Model I		Model II		Model III	
	Coef	Marginal effects (dy/dx)	Coef	Marginal effects (dy/dx)	Coef	Marginal effects (dy/dx)
Age of household head	-0.585*** (0.177)	-0.168	-0.722*** (0.222)	-0.233	-0.477*** (0.154)	-0.155
Age of household head squared	0.006*** (0.002)	0.002	0.007*** (0.002)	0.002	0.005*** (0.002)	0.001
Education of household head (years in school)	-0.203** (0.102)	-0.058	-0.283* (0.166)	-0.091	-0.276** (0.116)	-0.090
Number of dependants in a household	-0.042 (0.089)	-0.012	-0.103 (0.138)	-0.033	-0.140 (0.136)	-0.046
Log of land owned (hectares)	0.329 (0.258)	0.094	-0.148 (0.368)	-0.048	-1.057** (0.544)	-0.343
Log of labor cost in livestock production per season (Ushs)	-0.290*** (0.106)	-0.083	-0.222 (0.158)	-0.072	-0.167 (0.102)	-0.054
Number of extension visits per month	-0.146 (0.194)	-0.042	-0.235 (0.227)	-0.076	-0.305 (0.243)	-0.099
Log of distance to the market (km)	0.064 (0.230)	0.018	0.322 (0.333)	0.104	0.393 (0.348)	0.127
Membership to any farmers' group =1, 0 otherwise	2.558** (1.080)	0.643	3.801* (2.106)	0.874	3.152*** (1.073)	0.832
Access to any form of credit =1, 0 otherwise	1.637*** (0.685)	0.564	1.369 (0.869)	0.494	1.860* (1.092)	0.381
Experience in livestock production (years)	-0.008 (0.026)	-0.002	-0.021 (0.031)	-0.007	-0.063 (0.041)	-0.021
Number of local cows owned	-0.340*** (0.130)	-0.098	-0.463* (0.253)	-0.150	-0.291** (0.138)	-0.094
Number of local cows owned squared	0.013** (0.005)	0.004	0.017 (0.011)	0.005	0.014*** (0.005)	0.005
Number of improved cows owned	2.575*** (0.544)	0.738	1.572 (1.054)	0.508	-3.368* (1.828)	-1.093
Number of improved cows owned squared	-0.368*** (0.096)	-0.106	0.129 (0.240)	0.042	2.064*** (0.683)	0.670
Gross Margin (GM) X 10^{-5}	0.773*** (0.230)	0.222	0.759 (0.665)	0.245	0.176 (0.344)	0.057
Interaction of GM and number of local cows owned X 10^{-6}			-0.539 (2.200)	-0.174		
Interaction of GM and number of local cows owned squared X 10^{-7}			0.289 (1.19)	0.009		
Interaction of GM and number of improved cows owned X 10^{-4}			0.314** (0.158)	0.102	0.823*** (0.185)	0.267
Interaction of GM and number of improved cows owned squared X 10^{-4}			-0.106** (0.053)	-0.034	-0.283*** (0.065)	-0.092
Constant	14.577*** (4.294)		17.630*** (5.188)		14.057*** (3.842)	
Wald chi2	71.72***		94.16***		126.92***	
Pseudo R^2	0.816		0.845		0.816	
Number of observations	111		111		111	

Figures in parentheses are standard error. ***, ** and * imply significance levels at 1%, 5% and 10% respectively

Results in Model III indicate the likelihood ratio chi-square of 126.92 with a p-value of less than 0.01, which implies that the model as a whole is statistically significant. Since the probit estimates give the impact of the independent variables on the latent variable w_i^* as shown in equation (2a), not w_i itself, marginal effects will occasionally be referred to in the discussion. Marginal effects transform w_i^* into a probability estimate for w_i (Green, 2003). Results showed that the hypothesis that profitability of forage technology alone influences the decision to use IFT does not hold for farmers in Soroti district. Instead profitability contributes significantly to decision making involving the use of IFT when interacted with the improved cattle breed. The former finding appears to be inconsistent with earlier work of Sserunkuuma (2005) and Stefanides and Tauer (1999) that found that profitability of the technology significantly enhances the use of land technologies and growth hormones in dairy farms respectively. These two studies appear to have had no conditional factors; save for other factors included in their models, upon which to use the technology. Unlike in this study, farmers appear to make a decision to use the IFT conditional on rearing improved cattle and ultimately profitability. It is a widely known fact in Uganda that farmers with improved cattle either use rotational grazing method in paddocks or use zero grazing. The paddocks are usually with improved pastures and sometimes supplemented with grown forages such elephant grass. Where as zero grazing relies heavily on cut and carry of forages sometimes with concentrates, silage and hay.

In particular, the results on the interaction of GM and improved cows indicated an inverse relationship with the use of IFT. It should be noted that the small coefficients on the GM and its interaction terms do not imply that these variables are superfluous in the IFT model. This is because the GM values are very large compared to values of other variables. The most import aspect is sign of the coefficient. These results mean that an increase in the number of improved cows together with increased profitability enhance use of IFT significantly ($p<0.01$). But as the number of improved cows along with greater profitability increase beyond a certain point (the squared term), the likelihood to use IFT reduces substantially ($p<0.01$). This implies that number of improved cows and the profitability level are complementary factors livestock farmers consider when making the decision to use IFT. To further explain the negative effect in the inverse relationship, a large increase in the number of improved cows with increasing profits serves as an incentive for farmers to expand the scale of operation. That is, farmers are more likely to have more resources especially in terms of land and are likely to have sufficient land on which to graze, construct paddocks and hence reduce on IFT use. Their scale of operation may also be too large to allow them to plant forages and maintain efficient production due to diseconomies of scale.

Without the interaction effect of GM, however, the number of improved cows owned had a significant "U-shaped" relationship with the use of IFT. This means that farmers with fewer or no improved cows are less likely to use IFT, but the likelihood to use IFT increases as they acquire more improved cows. Specifically, from the regression results, livestock keepers begin to use IFT when they acquire one improved cow (From Table

4.7), using the coefficients on the number of improved cows and its squared term, $x = -(-3.368/2*2.064) = 0.816 \cong 1.00$)[4]. Similarly, using the First Order Condition procedure, livestock farmers with local cows less than ten are less likely to use IFT, but they do so after acquiring ten local cows. This is possible in the study area where farmers with fewer local cows could afford to graze them on the limited communal grazing land and other swampy areas. But as the herd size increases, there arises a need to supplement grazing with improved forages because of lack of sufficient grazing grounds. In addition, farmers with more local cows are the ones that are more likely to be keeping improved cows.

Other factors that had a significant impact on the decision to use IFT included age and education of the of household head, number of improved cows owned, access to credit, membership to farmers' group and the land size owned. Like for the number of cows owned, there was a significant "U-shaped" relationship between age and the use of IFT. The results showed that the likelihood to use IFT reduces significantly ($p<0.01$) by 15.5% until the farmer is 48 years old, when his/her chances of using IFT increases by 0.1%. In other words, the younger the household head, the less likely to use the IFT, but as the farmers grow older, the likelihood to use IFT increases. This finding is consistent with the earlier work of Adesina and Zinnah (1993); Adesina and Baidu-Forson (1995); and Fufa and Hassan (2006), who found that age reduces the probability of using agricultural technologies, Whereas Obonyo (2000) and Langyintuo and Mungoma (2008) reported a positive relationship between age and the use of

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[4] From First Order Conditions (FOC), for $Y = \beta_1 x + \beta_2 x^2$, FOC $\Rightarrow \partial Y/\partial x = \beta_1 + 2\beta_2 x = 0, \Rightarrow x = -\beta_1/2\beta_2$.

agricultural technologies. This implies that there is a non-linear relationship between age and the use of agricultural technologies (Rogers, 1983). In Soroti district, the younger farmers are less likely to be keeping cows. This may explain why they do not seem to use improved forage technologies. In addition, users of improved forage technologies are on average about one year older than the non-users of the improved forage technologies (Table 4.1).

The results in table 4.7 also indicated that the less educated the farmers were, the more likely they were to use the forage technologies. The marginal effects on the education variable indicated a significant reduction ($p<0.05$) of 9% on the probability to use IFT. This is contrary to expectation and to findings by some studies (Obonyo, 2000; McBride *et al.,* 2004; Mugisha *et al.,* 2004; Salasya *et al.,* 2007) which reported that education enhances the use of agricultural technologies because more educated farmers have a better opportunity to acquire and process information as well as understand the technical aspects of new technologies. However, the negative impact of education on use of IFT is possible where more highly educated farmer are engaged in gainful employment whose returns are higher than use of agricultural technologies (Sserunkuuma, 2005).

It was also observed that membership to farmer groups has a significant ($p<0.01$) and positive influence on use of IFT. This finding is similar to that of Mugisha *et al. (* 2004), who found that membership in an association significantly influenced adoption of IPM groundnut technologies in Eastern Uganda. The significant effect could be attributed to benefits enjoyed by members over non-members. Technology disseminators usually target the already organized farmers. Therefore, farmers in groups are more exposed to free inputs and technical knowledge as compared to their counter parts.

Results further indicated that access to credit by the IFT users had a positive but a weak impact ($p<0.1$) on use of forage technology. Access to credit increased the probability of using IFT by 38%. This agrees with the findings of Mugisha *et al.* (2004), that access to credit was positively related with adoption. Farmers should be able to access credit and other sources of income in order to use the improved forage technologies and all of the practices involved there in. This can be attributed to the fact that some of the investments (additional labor, and other inputs) need more money, which most of the potential users of the improved forage technologies do not have.

The significant and negative relationship between farm size and use of IFT, similar to the findings of Adesina and Zinnah (1993) and Langyintuo and Mungoma (2008) suggests that any additional land increase is either diverted to paddocking due to scale diseconomies of using IFT or allocated to crop production if dairy farming is less profitable. For every additional acre acquired, the probability to use IFT reduces by 34.3%. However, these findings are contrary to the work of Sevier and Lee (2004) who found a statistical significant correlation between adoption of precision farming technologies in citrus production and land ownership in Florida.

Surprisingly, the number of extension visits did not have significant effect on use of improved forage technologies. This result concurs with the work of Langyintuo and Mungoma (2008) where extension visits had substantial impact on the adoption of improved maize varieties in Zambia. This is possible where the technology and knowledge being disseminated by extension workers is irrelevant to livestock production. Other factors that had no significant impact on the use of the improved forage technologies included number of dependants in the household, labor cost, distance to the market and experience in livestock production.

4.7 Factors responsible for profitability of cattle enterprises in Soroti district

Some of the farmers among the respondents were found to own both local and improved breeds. Results in Table 4.8 show estimates of profitability model for the entire sample, i.e., pooled observations for farmers using IFT and those ones not using IFT. Model 1 represents estimates of equation (4). The results from Model 1 are conditional upon farmers' decision with respect to using IFT suggesting that the estimates are possibly subject to self-selection bias. Model 2 shows the estimates of equation (7) for which self-selection bias has been controlled for. Controlling for self-selection increased the magnitude of the IFT coefficient from 175250.10 to 274646.00 implying there was a negative self-selection bias (Wooldridge, 2002) in the profitability model. This finding conforms to the work of Stefanides and Tauer (1999) who found a similar result in milk production model after correcting for self-selection due to adoption of growth hormones in dairy farms. The discussion, thus, focuses on Model 2. The estimated model explains 56.4% of the variation in the dairy profitability model. The model has a highly significant F-statistic ($p<0.01$).

Based on the correlation matrix and the variance inflation factor (VIF), the models passed the test for multicollinearity. The heteroscedasticity problem was detected and fixed by removing four observations that appeared to be regression outliers, and leverage points identified using leverage-versus-squared-residual plot. This procedure, supplemented with variance estimators which are robust to heteroscedasticity (robust standard errors) solved the problem.

Table 4.8: Determinants of profitability of dairy cattle enterprises in Soroti district

Dependent variable=Gross Margin	Model 1		Model 2	
	Entire sample	Robust Std. Err.	Entire sample	Robust Std. Err.
Use of improved forage technology	175250.10	31466.39**	274646.00	35971.00***
Milking herd size	25185.56	20833.02	47648.74	16529.66***
Stocking density (cows per unit grazing area)	28.17	60.77	138.26	65.79**
Experience in livestock production (years)	-1899.38	1252.56	-1822.59	1186.49
Age of household head	9725.06	6973.60	12088.68	5870.91***
Age of household head squared	-86.29	76.51	-120.79	66.05*
Education of household head (years in school)	6239.92	3255.69*	4563.52	2745.79*
Number of dependants in a household	1677.65	4088.29	-1068.87	4228.78
Log of distance to the market (km)	7151.93	12376.94	5228.77	8056.41
Membership to any farmers' group =1, 0 otherwise	-2252.14	25081.32	-18749.78	20505.64
Access to any form of credit =1, 0 otherwise	-62707.03	34698.61*	-72576.89	35077.07**
Constant	-257260.90	142496.10**	-318524.70	117110.20***
F-value		5.58***		8.82***
R-squared		0.378		0.564
Number of observations		111		111

***, ** and * imply significant levels at 1%, 5% and 10% respectively. Figures in Parentheses are standard errors

The estimated coefficients for use of improved forage technologies suggest increased milk profitability level per cow per season, *ceteris paribus*. This is consistent with hypothesis that the use of improved forage technology substantially increases dairy profitability. This can be attributed to the fact that use of improved forage technologies amounts to better feeding of the animals, thus increasing milk output. Other variables significantly related to increased profitability were milking herd size ($p<0.01$) and stocking density ($p<0.05$). Earlier studies (McGilliard 1990; Ford and Shonkwiler 1994; Winsten, *et al.*, 2000) have shown similar findings that larger herd sizes are associated with increased profitability.

Stocking density was found to be significant ($p<0.05$) and positively related to profitability level. A higher stocking density leads to an increase in profitability levels. This is contrary to expectation. It was expected that an increase in stocking density reduces profitability due to diminishing returns resulting from increasing herd size on fixed grazing land, especially if the optimal stocking levels are exceeded. However, this finding is consistent with earlier findings of Kauffman and Tauer (1986) and Hadden and Johnson (1989) who found that increasing stocking density increased profitability in dairy farms. Moreover, increasing the number of cows on a farm increases dairy profitability (Gloy *et al.*, 2002)

The results further showed that the education of the household head was positively and significantly ($p<0.1$) associated with increased profitability. This is perhaps due to increase in the ability gained through education to execute management and make rational decisions. The results also indicated a weak inverse relationship between age and level of profitability. This tends to imply that younger farmers are more efficient in resource use than old farmers.

Access to credit had negative and significant ($p<0.05$) impact on the level of profitability. The negative impact of access to credit is also contrary to what was expected. A positive relationship between access to credit and profitability was expected, at least for the case of Soroti farmers. The plausible explanation for the negative impact is that farmers accessing credit may be re-allocating money or inputs obtained on credit (and more of their time) to profitable enterprises other than dairy enterprise.

4.8 Comparison of determinants of dairy enterprise profitability between users and non-users of improved forage technologies

Descriptive results indicated considerable factors differentiating farmers using improved forage and those using local technologies. In this section, farmers' characteristics and farm level factors important in explaining the variation in dairy profitability were identified with OLS regression analysis (Table 4.9). It should be noted that the interpretation of results in Table 4.9 is based on the strength and direction of the impact not the magnitude of the coefficients. This is because, although the dependent variable (Gross margin) was somewhat normally distributed, it had both negative and positive values.

The findings indicated that use of improved forage technology affected positively the profitability of cattle enterprises. These findings confirmed the expectation of this study. However, these results contradicted the findings of Foltz and Lang (2003) who found that greater technology use, despite the increases in productivity it yields, produces significantly lower profits in Northeastern Connecticut dairy farms. These two contradicting findings suggest that use of IFT may have non-linearity effects in the profitability model.

Table 4.9: Comparison of determinants of dairy profitability between users and non-users of improved forage technologies

Dependent variable=Gross Margin	Users of IFT	Robust Std. Err.	Non-users of IFT	Robust Std. Err.
Use of improved forage technology	414696.80	56926.68***	236742.00	46962.37***
Milking herd size	-87603.69	41033.85**	91433.23	20075.94***
Stocking density (cows per unit grazing area)	878.87	427.13**	67.05	56.11
Experience in livestock production (years)	-1001.11	2961.32	77.03	1046.14
Age of household head	28930.54	12001.25**	1554.35	6775.00
Age of household head squared	-285.19	144.15*	-26.33	67.36
Education of household head (years in school)	-8569.38	8167.00	912.83	3290.50
Number of dependants in a household	4728.39	7666.04	-514.93	4522.04
Log of distance to the market (km)	-39128.26	26998.36	22453.04	11329.26**
Membership to any farmers' group =1, 0 otherwise	-202414.90	67247.31***	4956.88	16831.15
Access to any form of credit =1, 0 otherwise	-113289.70	46293.95**	18157.00	34951.22
Constant	-391501.40	224880.40*	-139877.40	148472.10
F-value		8.97***		7.37***
R-squared		0.692		0.500
Number of observations		40		71

***, ** and * imply significant levels at 1%, 5% and 10% respectively. Figures in Parentheses are standard errors

Some key differentiating results were observed. Milking herd size considerably favored non-users of IFT more than their counterparts. The impact of the milking herd size estimate was more significant ($p<0.01$) for non-users of IFT compared to a significant ($p<0.05$) but negative impact for the users. This suggests that increased milk production and hence high profitability level for non-users of IFT would result from a larger milking herd size. This may hold since local cows are usually assumed to produce lower milk yield than improved cows. The negative effect of the number of milking cows on profitability for IFT users contradicts expectations. However, there are plausible explanations for this finding. It was observed in the study area that users of IFT owned at least one improved cow. These are largely smallholders faced with limited grazing area coupled with minimal or no use at all of concentrates and veterinary services due to their constrained financial resources. This was evidenced in the costs incurred for other inputs that included purchase of animal feeds, and veterinary services among others (see Table 4.4). It is not surprising given that users of IFT incurred as low as Ushs. 4,700 per cow per season in other input costs. Their other input costs incurred were even lower than the costs incurred by non-users of IFT though not significant. Since higher milk productivity of improved cows (and increased profitability) is associated with the use of improved animal feeds and regular veterinary services (Winsten *et al.*, 2000), it suffices to say that increasing milking herd size may reduce profitability if these inputs are minimally or not used at all. Thus, for livestock farmers in the study area who appeared to be in a similar financial squeeze to purchase necessary inputs, increasing milking herd size for improved cows would mean that their already limited amount of the required resources for the animals kept would be thinly distributed and thus become inadequate, leading to reduced animal productivity.

Stocking density (number of cows divided by the total area allocated to cattle grazing) was significant ($p<0.05$) and positively associated with increased profitability for users of IFT. Not surprising but a major finding is the positive and significant impact of stocking density associated with farmers using IFT. This finding explains the importance of using improved forage technology over local feeding methods. In other words, farmers using IFT can increase milk production and profitability without necessarily expanding the land allocated to grazing. This implies that the size of the grazing grounds is not as important as area allocated to forage growing for farmers using IFT. Secondly, improved forages act as supplements to the animals which are also grazed, implying that inadequate pasture land due to overstocking is compensated for by grown forages. This allows them to expand their stocking density without reducing their profit levels. The stocking density had an insignificant impact on the profitability for the non-users of IFT. Winsten *et al.* (2000) found similar results of stocking density having no impact on profitability of dairy farms.

Other factors that differentiated users of IFT from non-users included distance to the market which was significantly ($p<0.05$) associated with increased profitability for non-users, but it had no impact for users of IFT, and age of the household head which had a weakly significant ($p<0.1$) inverse relationship with the profitability level. Membership to farmer groups and access to credit were found to significantly ($p<0.01$ and $p<0.05$ respectively) and negatively affect the profitability for users of IFT, but had no impact on the profitability for non-users of IFT. This is surprising given the belief that knowledge which farmers obtain from groups is believed to helps them generate more profits from their agricultural enterprises.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary and conclusions

The study focused on socio-economic evaluation of forage technologies in smallholder dairy cattle systems in Soroti district, Uganda. The major objective was to asses the profitability of improved forage technologies in smallholder dairy cattle enterprises in Soroti district. Specifically the study aimed at comparing the profitability of dairy cattle enterprises using improved forage technologies with those using local technologies; determining the factors affecting the use of improved forage technologies among smallholder dairy farmers in Soroti District; and identifying and comparing the factors responsible for profitability of dairy cattle enterprises using improved forage technologies with those using local technology.

The study was conducted in Soroti district in Eastern Uganda, in Gweri and Arapai sub-counties that were purposively selected. Data were collected using pre-tested questionnaires. A random sample of 121 farmers of whom 43 were using improved forage technologies participated in this study. The analytical tools used included descriptive statistics, partial budget analyses, the probit model, and the Ordinary Least Squares (OLS).

Descriptive results showed that farmers using improved forage technologies had the lowest total production costs per cow per season, but with the highest average milk production per cow per season compared to the farmers using traditional technology. The partial budget results confirmed this and indicated that farmers using improved forage technologies (IFT) had significantly higher revenue and gross margin, five times bigger than that of farmers using traditional technologies. The implication is that farmers using IFT are more efficient in resource use than their counterparts. These results support the hypothesis that improved forage technologies were more profitable than the traditional technologies for small holder dairy cattle feeding in Soroti district. However, both the farmers who used the traditional technologies and those who used IFT had a positive gross margin. This implies that the dairy cattle enterprises are profitable irrespective of the type of forage technology used.

Results of the probit model showed that using the technology profitability alone among other variables does not explain a significant variation in the use of forage technology. Instead the contribution of profitability in influencing decision to use IFT is conditional on the type of cattle breed owned. The results showed that the interaction effect of profitability and improved cattle is very important in influencing the decision to use IFT. A positive relationship between the number of improved cows and use of IFT indicates that economies of scale are dominant throughout the herd size distribution. However, after accounting for interaction effect between profitability and improved cattle breed, the findings indicated that the inverse relationship dominates the economies of scale up to acquiring one improved cow. The implication is that the type of cattle breed and profitability of the technology are key interdependent factors in influencing the farmers' decision to use IFT.

The study results also confirmed the findings of previous research showing age, educational level of the household head and the size of land owned as very important factors in reducing the probability to use IFT. Access to credit and membership to farmer group greatly increase the likelihood of using improved forage technologies.

A simple comparison of the gross margin using Ordinary Least Squares (OLS) regression analysis showed that the average gross margin for farmers using IFT is numerically higher than the average gross margin for farmers not using IFT. This resulted in the conclusion that "non-use" of IFT is as not as profitable as the use of IFT.

Results indicated that use of predicted probability of improved forage technology, and milking herd size significantly increased profitability levels regardless whether the farmer used IFT or not. Much of the difference between profitability levels for IFT users and non-users was attributed to milking herd size that benefited IFT non-users, stocking density which favored IFT users, and age of the household head which favored IFT users. Membership to farmer group and access to credit negatively affected profitability for IFT users but had no impact on IFT non-users, while distance to the market favored IFT non-users. These differentiating factors suggest that farmers may or may not use improved forage technologies and still be able to obtain profits.

However, it should be noted this study used data from two seasons (one year) and from a small sample size to measure profitability. Yet the decision to use or adopt improved forage technology has long-term impacts.

5.2 Recommendations

Although smallholder dairy cattle enterprises were profitable whether the farmer used IFT or local feeding technologies, the difference in the returns was significantly higher for IFT users. Therefore policy makers and agencies disseminating forage technologies should aim at provision of extension services that are result-based with demonstrations to encourage farmers to use improved forage technologies. Farmers rearing traditional cattle are the majority. The policies therefore should be inclusive of those who are exclusively rearing traditional cattle. The policy interventions should be not only providing extension services but also intensive training in forage use and its importance. In addition, farmers should be availed with the necessary inputs especially forage seed, and trained in how to multiply these on their own.

Group formation should also be encouraged by the extension agents because farmers are easier to reach and are more organized in groups. In addition, dissemination of improved forage technologies should focus more on older farmers (about 48 years of age and above), since these are the ones more likely to adopt the technologies, perhaps due to their access to more resources. Policies targeting increasing credit markets in rural areas and those that target farmer group formation are needed in order to enhance the use of IFT.

Improved forage technologies can also be recommended as possible ways of reducing degradation of agricultural land through over stocking which leads to over-grazing. Supplementing grazing with the planted forages reduces grazing pressure on the land, and allows the farmers to have a higher stocking density without lacking feeds, or lowering profitability of the enterprise though diseconomies of scale.

5.3 Recommendations for further studies

Impact studies that consider long-terms impacts should be carried out using larger samples, and similar studies as this one carried out in other areas. In addition, there are many improved forage technologies which could perform differently in different areas depending on soils, weather, and climatic conditions among others. Studies should therefore be carried out to evaluate their performance and find out where they perform best.

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APPENDICES

Appendix 1:

Testing for exogeneity of Gross Margin (GM) in the use of (IFT) model

This followed a procedure in Wooldridge (2002), page 474. This was done by first testing the null hypothesis that Gross Margin is exogenous in the use of improved forage technology model, i.e., H_0: $\phi = 0$. If $\phi \neq 0$, then usual probit standard errors and test statistics are not strictly valid. Where ϕ is the coefficient on the residuals as empirically in the following procedure:

Step I: Ordinary Least Squares (OLS) regression was run using Gross Margin as dependent variable and a set of explanatory variables (defined in Section 3.4.3.1). Residuals $(r\hat{e}s)$ were then predicted from OLS model as follows:

```
. reg GM lgmilkafter lgttnumcows stokdensity yearslivest lbrcostafter lgothercosts
hhage hhsch ///
> dependants lgdistmarket farmergroup crediaccess milktransport vetservice,r

Linear regression                                      Number of obs =      115
                                                       F( 14,    100) =    29.65
                                                       Prob > F      =   0.0000
                                                       R-squared     =   0.8053
                                                       Root MSE      =    98901

------------------------------------------------------------------------------
             |               Robust
          GM |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 lgmilkafter |   174111.2    17397.61    10.01   0.000     139594.9    208627.6
 lgttnumcows |   49050.78     12598.7     3.89   0.000     24055.33    74046.24
 stokdensity |  -211.2332    96.77304    -2.18   0.031    -403.2281   -19.23823
 yearslivest |  -928.0578    944.5151    -0.98   0.328    -2801.949    945.8332
lbrcostafter |  -1.162572     .320781    -3.62   0.000    -1.798992   -.5261512
lgothercosts |  -3450.139    1677.565    -2.06   0.042     -6778.38   -121.8991
       hhage |  -34.05833    994.4095    -0.03   0.973    -2006.938    1938.822
       hhsch |   5827.474    3641.035     1.60   0.113    -1396.235    13051.18
  dependants |    1300.51    2649.572     0.49   0.625    -3956.165    6557.185
lgdistmarket |   5047.594    9645.357     0.52   0.602    -14088.52    24183.71
 farmergroup |  -32620.98    18303.47    -1.78   0.078    -68934.55    3692.589
 crediaccess |   11730.63    31964.73     0.37   0.714    -51686.48    75147.74
milktransp~t |  -35293.82    15572.97    -2.27   0.026    -66190.14   -4397.496
  vetservice |  -28314.91    25714.41    -1.10   0.273    -79331.56    22701.75
       _cons |  -760595.7    113329.8    -6.71   0.000    -985438.8   -535752.7
------------------------------------------------------------------------------
```

Step II: The probit model of "use of improved forage technologies" was run on the explanatory variables indicated in equation 3 with the predicted residuals $(\hat{res})$

```
. probit adopt hhage hhage2 hhsch dependants lgtotlandownha loclcows loclcows2 ///
> improvedcows improvedcows2 lglbrcostafter visited ///
> lgdistmarket farmergroup crediaccess GM res yearslivest,r

Probit regression                                 Number of obs   =        115
                                                  Wald chi2(17)   =      60.00
                                                  Prob > chi2     =     0.0000
Log pseudolikelihood = -30.458306                 Pseudo R2       =     0.5965
------------------------------------------------------------------------------
             |               Robust
       adopt |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       hhage |  -.1620817   .0883844    -1.83   0.067    -.3353119    .0111484
      hhage2 |   .0014523   .0009646     1.51   0.132    -.0004383    .0033429
       hhsch |  -.0434867   .0531958    -0.82   0.414    -.1477486    .0607751
  dependants |  -.0800314   .0573535    -1.40   0.163    -.1924421    .0323793
lgtotlando~a |   .1947753   .2327771     0.84   0.403    -.2614594      .65101
    loclcows |  -.0154801   .0462809    -0.33   0.738     -.106189    .0752287
   loclcows2 |    .001013   .0007891     1.28   0.199    -.0005336    .0025596
improvedcows |   1.401784   .3484227     4.02   0.000     .7188877    2.084679
improvedco~2 |  -.2117314   .0743274    -2.85   0.004    -.3574104   -.0660524
lglbrcosta~r |  -.1687573   .0749404    -2.25   0.024    -.3156377   -.0218768
     visited |    .025363   .0555172     0.46   0.648    -.0834487    .1341748
lgdistmarket |   .0300634   .2901604     0.10   0.917    -.5386405    .5987674
 farmergroup |   .9673072   .4329171     2.23   0.025     .1188054    1.815809
 crediaccess |   .8058036   .4805899     1.68   0.094    -.1361353    1.747742
          GM |   2.78e-06   1.15e-06     2.40   0.016     5.13e-07    5.04e-06
         res |   1.53e-06   2.60e-06     0.59   0.556    -3.57e-06    6.63e-06
 yearslivest |  -.0020115   .0171016    -0.12   0.906    -.0355301     .031507
       _cons |     4.1314   2.009448     2.06   0.040     .1929551    8.069846
------------------------------------------------------------------------------
```

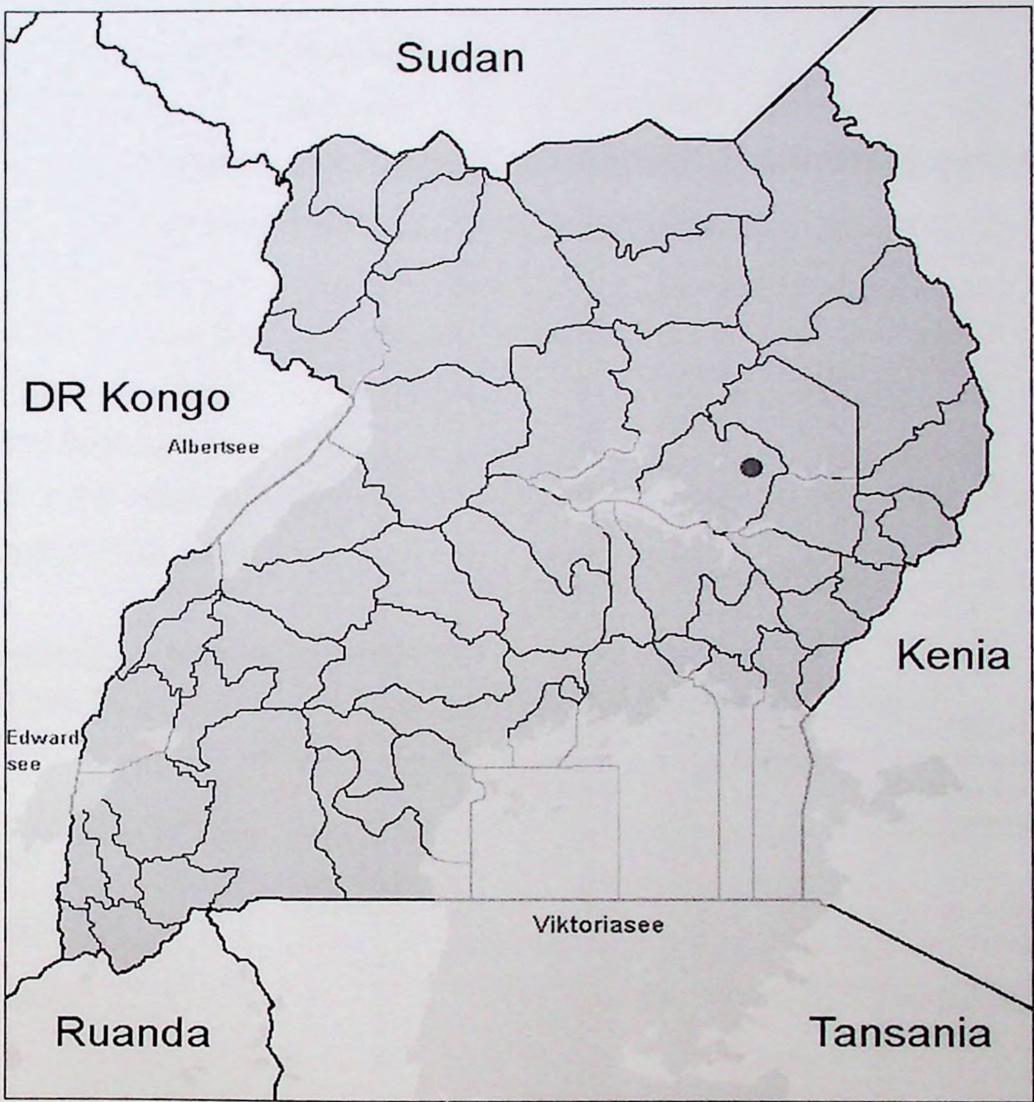
From the results above the *z* statistic on $(\hat{res})$ is 0.59, which is weak evidence to reject the null hypothesis that GM is exogenous.

Appendix 2: Tests for interaction effect between cattle breed and profitability

(Details of these tests are in Wooldridge, 2002 and Greene, 2003)

Likelihood Ratio test	**LR Chi square value**	**p-value**
Model with Interaction of GM and number of local cows owned plus Interaction of GM and number of local cows owned squared against the one without	0.89	0.6404
Model with Interaction of GM and number of improved cows owned plus Interaction of GM and number of improved cows owned squared against the one without	12.40	0.0020
Model with all the four Interactions against the one without	13.34	0.0097
Lagrange Multiplier test	**Simultaneous test score value**	
Model with Interaction of GM and number of local cows owned plus Interaction of GM and number of local cows owned squared omitted	7.57	0.0227
Model with Interaction of GM and number of improved cows owned plus Interaction of GM and number of improved cows owned squared omitted	18.93	0.0001
Model with all the four Interactions omitted	21.16	0.0003
Wald test	**Chi square value**	
Wald test on the Interaction of GM and number of local cows owned plus Interaction of GM and number of local cows owned squared	1.17	0.5558
Wald test on the Interaction of GM and number of improved cows owned plus Interaction of GM and number of improved cows owned squared omitted	5.86	0.0533
Wald test on the all the four Interactions omitted	6.24	0.1820

Appendix 3: A MAP 0F UGANDA, SHOWING THE LOCATION OF SOROTI DISTRICT



● Soroti District

APPENDIX 4: FARM HOUSEHOLD QUESTIONNAIRE

QUESTIONNAIRE ON ECONOMIC EVALUATION OF FORAGE TECHNOLOGIES IN SMALLHOLDER DAIRY CATTLE SYSTEMS IN SOROTI DISTRICT, UGANDA

1. BACK GROUND INFORMATION

Name of interview .....Start time..................End time................................

1.1. Name of respondent....... 1.2. Respondent number.... 1.3Adopter/Non-adopter ......

1.4 Sex [1] Male [2] Female 1.5 Date of interview..

1.5.County..

1.6 Sub-County..

1.7Parish..

1.8 Village/Zone.........................

1.9. Title in the household (tick the appropriate) [1]. Head [2]. Partner [3]. Child [4]. Dependant [5]. Other.................................

2. HOUSEHOLD CHARACTERISTICS

2.1 Please fill in the table below with information about your household

	Sex 1. male 2. female	**Age (Years)**	**Marital status**	**Years in school (Years)**	**Current occupation**	**Estimated income got from the occupation (Ug Shs per month)**
Household head						
Partner (s)						
Dependant (s)				Total number active in animal husbandry work	Part time farm workers	Permanent farm Laborers
Infants not yet in school						
In Nursery						
In primary						
In secondary						
Tertiary						
Other children not in school						

Key: Marital status 1. Married 2. Single 3. Widowed 4. Divorced

2.2. Who is the major decision maker in your family? Father 2. Mother 3. Uncle 4. Aunt 5. Joint 6. others (specify)

2.3. Does the household head have any positions of responsibility in the area/community?

1. Yes 2. No

2.4. If yes state them 1............................... 2...

3. LAND USE AND AGRICULTURAL PRODUCTION

3.1.

	Area (Ha)			Cost of land (Ug Shs/Ha)	Mode of acquisition (Codes)	Farmers production goals (Codes)
	owned	Rented	Borrowed			
Total area						
Total land area for cattle						
Land area for cultivation						
In your home, who decides whether a technology is taken up or not?				man	Woman	Both

Mode. 1. Inherited 2. Purchased 3. Hired 4. Given (Gift) 5. Borrowed 6. Other (Specify

Goals 1. Subsistence. 2. Commercial 3. Both 4. Others (specify)...........................

3.2. How many years have you spent in livestock production? .... years

3.3. How many cows do you have?.......................... local cow.....................improved cows

4 INFORMATION ON FORAGE TECHNOLOGIES

4.1. List the forage technologies you have used on your cattle (including the ones that are currently not being used, but were once used).

forage technology taken up (see code sheet)	Year of adoption	Source of the improved forage technology (source)	Method of dissemination	Other service obtained from organization

Source 1. NaLIRRI project 2. SOCADIDO 3. Send a Cow 4. NAADS 5. Fellow farmers 6. District agriculture office 7. Others (Specify**)**

Method 1. Farmer-to-farmer delivery, 2. Expert visits to individuals 3. Expert visits to farmer groups 4. Print 5. radio, and television

Other Service 1. Free seeds 2. Credit services 3. Free advice on other problems (Indicate them) 4. Others (specify)

4.2. For the forage technologies that you took up and still have, those that you took up and dropped, and those that were disseminated in your area but you did not take them up at all, fill in the table below

Technology	**Disseminating institution**	**Status 1.** Still in use 2. Was dropped 3.Available, but not taken up at all	**Technologies that are still being used**	**Technologies that were dropped**	**Technologies that were available, but not taken up at all**
			reasons that led the farmer to retain it	Reasons for dropping the technology	Reason for not taking them up

Reasons: 1. Easier establishment 2. More knowledge/information about it 3. Easier forage seed availability 4. High costs of seed 5.Easy access of other inputs (specify) 6. Lack of inputs/difficult to access 7. Economization of land (Can be intercropped with other food crops) 8. Lack of enough land 9. Low prices for the milk 10. Lack of market for the milk 11. Not enough labor to carry out the practices 12. Too labor intensive 13. Others (Specify)

4.3. For each of the forage technologies that you have taken up and are still using, indicate what practices were taught for that technology, those that you took up, and those that you did not

Forage technology	**Practices taught/that came with the technology**	**Taken up or not 1. Yes 2. No**	**Reason(s) for taking up /not taking up**

Practices. 1. Use of the grass –legume mixture 2. Drying and storing feed (Hay), 3. Chopping feed before feeding 4. Others (Specify)

Reasons 1. Lack of seed 2. Too labour intensive 3. Lack of enough knowledge 4. No interest 5. Lack enough land 6. Others (specify)

4.4. For the above forage technologies, indicate how you carry out the practices (if it is different from the taught way)

Forage technology	Practices (Codes)	Why its is done this way

Practices: 1. Uses grass only 2. Uses the grass only 3. Never dries and stores the feeds 4. Others (Specify)

4.5. For the forage technologies that you took up, indicate the characteristics that you like and those that you do not like about them

Forage technology	Perceived good characteristics	Perceived bad characteristics

4.6. What difficulties do you meet in integrating the improved forage technologies into your current farming practices?

Improved forage technology	Difficulties faced in integrating into the farming system?

5. INPUT REQUIREMENTS AND COSTS OF PRODUCTION

5.1. For the forage technologies used in the last season, give the cost of the activities involved in carrying them out.

Forage technology	Area under forages (Acres)	Activities	Number of days per activity	Number of workers per day				Amount paid per worker (Ug Shs)		Total cost of activity
				family		Hired				
				C	A	C	A	C	A	

Key: C= Child **A**= Adult Men/women >18yrs; **1 man-day** = 6 person hours for a man, = (0.75*6) person hours for a woman = 12 person hour for a child. **Season** = time between plating and harvesting the forages.

Activities: Bush clearing. 2. Ploughing 3. Planting 4. Weeding 5. Harvesting 6. Drying and storage 7. Feeding and looking after animals 8. Others (Specify)

5.2. If any forage technologies were taken up, indicate the cost of the same activities before the technologies were taken up

Activities	Number of days per activity	Number of workers per day				Amount paid per worker (Ug Shs)		Total cost of activity
		family		Hired				
		C	A	C	A	C	A	

5.3 Please indicate the amount of forages you were feeding the animals before and after the forage technologies were introduced

forage technology	Amount of feed fed during last forage season	Estimated cost (Ushs)	Amount of feed fed before the forage technology was taken up	Estimated cost (Ushs)

5.4. Fill in the following table about the source and amount of seed and other inputs for the activities involved in production of the forages during the last forage season

Forage Technology	Input(s)	Source	Quantity used (Kg)	Total cost of the input
Traditional forage technology				

Input; 1. Seed 2. Veterinary services 3. Others (specify)

Source: 1. Given by NaLIRRI 2.Local market 3. Seed and input stockist 4. Fellow farmer 5. Research station 6. Others (specify)

5.5. Which is the most important source finance for your inputs? ....

1. Own capital 2. Fellow farmers 3. Microfinance institution 4. Farmers' group 5. Cooperative group 6. Others (specify)

6. INFORMATION ON OUTPUT

6.1. For both local and improved cows on which these forage technologies are being applied, indicate the milk output before and after use of the forage technologies

Local cows				Improved cows			
Number of cows	Technology (Use codes)	Average milk output per cow per month		Number of cows	Technology (Use codes)	Average milk output per cow per month	
		After taking up the technology	before taking up the technology			After taking up the technology	before taking up the technology

6.2. For the forage technologies where the forages are inter-planted with food crops indicate the quantity of the food crops produced from the same piece of land before and after the forage technologies were taken up, and the value of the output.

Technology	**Food crop**	**Output last season**	**Output before the crop was intercropped with a legume**	**Quantity of output sold last season**	**Cost per Kg**	**Quantity consumed (kept)**	**Total revenue from food crop**
	Sorghum						
	Maize						
	Cow peas						

6.3. How much manure do you get from your animals per month? .... (Kg)

6.4. Do you sell your manure? 1. Yes 2. No

6.5. How much do you get from your manure per kg? .... (Shs)

6.6. Amount sold in the last season..Kg

6.7. Amount used at home in the last season..Kg

6.8. What was the cow's calving interval before and after taking up the forage technologies?

Technology used	Local cows		Improved cows	
	Calving interval before	Calving interval After	Calving interval Before	Calving interval after

7 MARKETING

7.1. Of the milk produced during the last forage season (when forages were being fed), indicate how much was sold, and how much was consumed daily

Total amount of milk produced per day	**Amount consumed at home (Liters)**	**Amount sold per day**	**Point of sale** 1. Home 2. Collection centre 3. Market 4. Others (Specify)	**Price per liter(UShs)**	**Total revenue from milk per day**

7.2. What is your opinion about the current pries received from sale of milk?

1. Good 2. Fair 3. Bad

7.3. Why do you think so?

....

7.4. How do you think the situation (of milk prices) can be helped?

....

7.5. How do you transport your milk to the market? **Transport means** 1. Bicycle 2. Head 3. Vehicle 4. Others (specify)

7.6. How much is the transport from your home to the market by car? ....Bicycle .....manual carrying ....Ug Shs?

7.7. Indicate other costs involved e.g. transport, market dues in selling your milk for the last season

Marketing Activity	Costs Incurred

Activity: 1. Transportation 2. Market dues 3. Others (specify)

7.8.Do you sell some of your harvested livestock feeds? 1. Yes 2. No

7.9 . If yes, indicate the quantities sold in the last forage planting season

Forage technology	Quantity harvested	Quantity sold (kg)	Quantity given out (kg)	Price per unit	Total revenue generated

8. GENERAL INFORMATION

8.1. A part from the organizations that have been disseminating the improved forage technologies had you been informed, trained or given extension services on improved forage technologies about them before? 1. Yes 2. No

8.2. If yes by whom 1. NAADS 2. NGOs (specify) 3. Cooperative group 4. Others (specify)

8.3. What are your major sources of information about agricultural activities?.................

Sources: 1. District Agricultural offices 2. NAADS 3. Cooperative group 4. Farmers' group 5. Others (Specify)

8.4. How many times are you been visited by an extension agent/ veterinary service provider in a month?............times

8.5. How many times do you visit an extension agent in a month?.................times

8.6. Estimate your total seasonal income (Ug Shs) from the following sources.

Economic activity	**Income generated (Indicate whether per month, or per season, etc)**
1.Livestock Production	
2. crop production	
3.Non- farm activities	
4.Remittances	
5. Others (specify)	

8.7 .Distance of your home stead from the nearest of the following places

Area	Distance (Km)
District head quarters	
Sub- county head quarters	
Town	
Trading center	
Main road	
Access/feeder road	
Market	
School	
Health center	

8.8. Do you belong to any farmers' group? (Credit group, Cooperative group, etc)

1. Yes 2. No

8.9. If yes, specify the group or association.

Group : 1. Extension contact group 2. Farmers' Association 3. Cooperative group 4. Savings and credit group 5. Others (specify)

8.10 . Why did you join the group/Association?

....

8.11. For how long have you been in the association/group? ....Months

8.12. Do you have access to any form of credit? 1. Yes 2. No

8.13. If you have received credit in the last year, fill the table below

Amount received	Enterprises in which invested	Sources of credit (Codes)

Credit source; 1. Bank 2. Microfinance institutions 3. Local cooperatives 4. Friends 5. Others (specify....................................

8.14. What is your opinion about improved forage technologies in Soroti district generally? ....

8.15. What do you think can be done to improve forage technology dissemination in this area? ....

8.16. What crops/enterprises would you have planted in the land where there are forages if you had no allocated it to forages?...

8.17 In your opinion, Since taking up the forage technology, has the revenue from your cattle enterprise 1. increased, 2. reduced, or 3. Stayed the same?

8.18 Why do you think it is so?...

Codes for the forage technologies

Technology	Codes
Maize/cowpeas intercrop	1
Maize/lablab intercrop	2
Sorghum/lablab intercrop	3
Sorghum/cowpeas intercrop	4
Chloris gayana/Desmodium/ Siratro intercrop	5
Elephant grass/Desmodium intortum mixture	6
grazing supplemented with elephant grass	7
Local grass(Traditional forage technology)	8

* 1-7 are termed "Improved forage technologies", while 8 is the traditional/local forage technology

END

THANK YOU