SOCIO-ECONOMIC FACTORS INFLUENCING ADOPTION OF CALLIANDRA AND LEUCEANA SHRUBS AS FEED SUPPLEMENTS AMONG THE SMALL HOLDER DAIRY FARMERS IN KISII CENTRAL SUB-COUNTY, KENYA.

BY

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DECLARATION

Declaration by the Student

This thesis is my original work and has not been presented for a degree in any other university. The materials cited here which are not my original work have been acknowledged. No part of this thesis shall be reproduced without the prior permission of the author and /or Moi University.

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Dedicated to Mary Wanjiru John, Jasper and Artemus.

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ABSTRACT

Calliandra (*Calliandra calothyrsus*) and Leuceana species are the mostly widely promoted and adopted exotic fodder shrubs in Kenya and are the most popular species in Kisii Central Sub-County. However, despite their multiple benefits and economic viability, the adoption of these fodder species for use as dairy feed supplements among the small holder dairy farmers in Kisii Central Sub-County has been low. The specific objectives of this study were to compare the socio-economic characteristics of adopters and non-adopters of Calliandra and Leuceana species in Kisii Central Sub-County, determine socio- economic factors that influence their adoption and to make policy recommendations on strategies to enhance their adoption. The study was based on the main hypothesis that adoption of Calliandra and Leuceana shrubs as feed supplements was not influenced by farmer's socio-economic characteristics. The research design was descriptive survey and household interviews and questionnaires were the main data collection tools. The study used a sample of 116 smallholder dairy farmer's selected using stratified random sampling from four randomly selected villages from Kisii Central Sub-County, in Kenya. The sample was stratified by gender strata to ensure proportionate representation of female headed households among the adopters and non- adopters. The choice by the individual farmer to adopt was assumed to be "either-or" in nature (dummy dependent variable), hence the use of a statistical model of discrete choice, called the Logit model. To produce unbiased parameter estimates, maximum likelihood estimation method was applied. The empirical results showed the farmers' decision to adopt were positively and significantly affected by Sex of the Household Head, Family Size, Extension Contact, and Dairy Breed Quality. On the other hand, effect of Age of the Household Head and Presence of other Income Generating Enterprises within the Farm were negative but not significant. The overall mean probability of adoption was 0.31 (31%) whereas the mean probability of an adopter was 0.76 (76%).The mean probability ofa non- adopter was 0.1 (10.8%). A singe policy change leading to increased extension contact with the dairy farmers had the greatest impact of increasing the adoption rate to 44.6%, while improving the dairy quality had the smallest impact of increasing the adoption rate to 38.2% among the significant determinants. Combining several policies yielded better impacts due to interactive effects. It was therefore recommended that the government and other extension providers should consider formulating policy strategies which enhanced livestock extension services intensification. A policy on affirmative action targeting female headed households should also be considered alongside affordable and accessible artificial insemination services to improve dairy breed quality. The suggested policy interventions could provide viable and long term solutions to the underlying constraints inhibiting this technology adoption among the smallholder dairy farmers in Kisii Central Sub-County.

DEFINITION OF TERMS

Adoption: - This refers to the acceptance, establishment and use of Calliandra and Leuceana shrubs as dairy feed supplements by a farmer after going through a mental process of decision making.

Extensionist: - Any person who delivers agricultural, livestock or agro-forestry extension information or messages to farmers

Small Holder Dairy farmer:-Dairy farmerwith land parcel of one hectare or less whose main occupation and source of livelihood is farming.

Socio-economic factors: - these refer to the household characteristics, social and natural capital and market access

Technology:-The combination of Knowledge, inputs and management practices which are deployed together with productive resources to produce a defined output.

Level of adoption: in this study this is the percentage of farmers who have adopted exotic fodder shrubs.

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LIST OF ACRONYMS

GoK	-	Government of Kenya
ICRAF	-	International Centre for Research in Agro-forestry
KARI	-	Kenya Agricultural Research Institute
LH_1	-	Lower Highland 1
LH_2	-	Lower Highland 2
UM_1	-	Upper midland 1
LM_1	-	Lower Mid land 1
LPM	-	Linear Probability Model
MOLD	-	Ministry of Livestock Development
NALEP	-	National Agriculture and Livestock Extension Programme
SDCP	-	Smallholder Dairy Commercialization Project

CHAPTER 1

Introduction

1.0 Introduction

This chapter presents the introduction of the study. Section1.1 of this chapter presents detailed background information of the study whereas section 1.2 presents theproblem statement. The study objectives are presented in section 1.3with section 1.4presenting the hypotheses of the study. Justification of the Study is covered in section 1.5 with section 1.6presenting the study area. Assumptions and Scope of the study are presented in section 1.7 and 1.8 respectively.

1.1 Background Information

Improved low input livestock management technologies are recognized as key ways of improving and sustaining productivity among small scale livestock farmers in Africa (Smith*et al*., 1997).It is with this background that selected exotic fodder shrubs notably Calliandra and Leuceana species were introduced into Kisii Central Sub-Countyof Kenya in 1987to be used as protein feed supplements for dairy cows or dairy meal substitutes by the smallholder dairy farmers (GoK-MOLD, 1990).Their clear benefits have resulted in their wide spread adoption in many parts of East Africa (Wambugu *et al*., 2006).

Most of these smallholder farmers could not afford to buy the dairy meal (a well-balanced dairy concentrate) due to its high cost. The shrubs were therefore meant to mitigate against the problems of dairy feed quality and increasing cost of the manufactured dairy concentrates. Since 1987, Calliandra and Leuceana shrubs have been extensively promoted in the Sub-County as protein supplement for dairy animals by various development agencies. These include KARI Kisii, Ministry of Livestock

Development, National Dairy Development Programme, Livestock Development Programme and International Centre for Research in Agro-forestry (ICRAF).

According to Wambugu *et al*., (2006), two options for feeding Calliandra and Leuceana shrubs exist. Theycan be used as a supplement to basal diet or as a substitute. When used as supplement, Calliandra is fed in addition to the existing basal diet, which may or may not include dairy meal. The cow's diet thus remains the same except that Calliandra is added. The farmer does not use Calliandra to replace dairy meal or any other component in the cow's diet; rather it is viewed as an additional supplement. Supplements are not supposed to exceed25% of the diets dry matter, otherwise they become a substitute (Crabtree and Williams, 1971).When used as substitutes, farmers use Calliandra instead of dairy meal. They thus perceive the benefits of Calliandra to be the money they save from not having to buy dairy meal.

According to Place *et al*., (2002), there is need for an improved understanding of the smallholder's needs, socio- economic constraints and practices. This understanding is important since it is a prerequisite for anyextensionor research systems being effective in improving the livelihoods of the smallholder dairy farmers in Africa. Therefore, understanding howthese small holder dairy farmers make their adoption decisions will constitute importantcontribution to the future promotionand dissemination of this technology. This could lead to increased dairy productivity and hence improved livelihood among the smallholder dairy farmers in the Sub-County.

Liu (2007) believed that adoption studies of new technologies could be the key to understanding the persistent poverty of subsistence farmers in less developed countries. Ofreneo (2004), points in his study that the slow diffusion of new technologies in the agricultural sector in less developed countries has long been a puzzle to development economists hence the need for more empirical work in these areas.

While most of the current empirical research on technology adoption focuses on credit constraints and learning spillovers(Mutai*et al.*, 2007; Teklewold *et al.*, 2006; Suri ,2005 and Croppenstedt *et al.*,2003),this study examined the role of other socio- economic constraints in the decision to adopt and use fodder shrub as feed supplements in Kisii Central Sub-County.

In this study, the interest was in explaining why a particularchoice (in this case, adoption and use of Calliandra and Leuceana shrubs as dairy feed supplements) is made by the smallholder dairy farmers and what factors enter into the decision process. There was also the need to find out how much each factor affected the outcome and to what extent. It was expected that the various socio-economic factors influencing farmer's adoption of this technology will be determined together with the percentage adopters, and non-adopters.

1.2 Statement of the Problem

Calliandra and Leuceana fodder species when used as dairy feed supplements have multiple benefits. These benefits includes; increased milk hence more money from the sale of extra milk, cost saving by reducing or eliminating the need to purchase costly manufactured supplements such as dairy meal, theyalso use land which is not suiTable for other crops and they save time and energy as they are available within the farm.

These benefits have led to their rapid and widespread uptake by small holder dairy farmers in most parts of Kenya. This has resulted in their high adoption rate in Kenya's densely populated highlands of Central and parts of Eastern regions of Kenya (Wambugu *et al.*, 2006).

However, the adoption ofCalliandra and Leuceana fodder species for use as dairy feed supplements among the small holder dairy farmers in Kisii Central Sub-County has been low. According to the Kisii Sub-Countylivestock annual report, the numbers of these shrubs are estimated to be about 24,550 shrubs (0.14%) against requirement of 17,511,500 shrubs for the Sub-County's estimated 35,025 dairy cows (GoK-MOLD, 2006). This translates to a deficit of17, 486,950shrubs (99.85%). This is despite the fact that their use as feed supplement is economically profitable (Koech, 2004). In addition, other ideal conditions for their adoption such as climate, relatively small land sizes, high dairy population and zero grazing practices exist in Kisii Central Sub-County.

According to Koech (2004), dairy farmers may fail to adopt a new technology due to various socio-economic constraints confronting them.However, these socio-economic constraints facing these small holder dairy farmers are neither known nor fully understood by the various promoters of these fodder shrubs in Kisii Central Sub-County. This lack of understanding has resulted in little attention being given to socio- economic issues in the promotion of this technology as well as in its extension or dissemination.
It is thus crucial to understand the influence of the various socio-economic factors on the adoption of Calliandra and Leuceana fodder species in Kisii Central Sub-County with view of improving the adoption level of this technology among the smallholder dairy farmers in the Sub-County.

1.3 Objectives of the Study

The broad objective of this study was to determine the socio-economic factors that constrain the adoption of Calliandra and Leuceana shrubs as dairy supplements in Kisii Central Sub-County by the small holder dairy farmers. The specific objectives of this study included:-

i) To determine if the mean values of adopters and non-adopters' socio-economic characteristics are different.

ii) To understand adoption constraints and determine socio-economic factors that significantly influence the adoption of fodder shrubs as feed supplements among the small holder dairy farmers.

iii) To investigate effects and impacts of various policy interventions on the adoption level of Calliandra and Leuceana.

1.4 Hypotheses for the Study

The following hypotheses were formulated and tested in relation to the objectives of the study:

1.3.1 The mean values of Calliandra and Leuceana adopters and non-adopters' socio-economic characteristics are not significantly different.

H_0: $\mu_{i1} = \mu_{i2}$

H_1: $\mu_{i1} \neq \mu_{i2}$

Where, μ_1 is the population mean of adopters, μ_2 is the population mean of non-adopters. Where i=1, 2, 3………………k.

1.3.2 Adoption ofCalliandra and Leuceanafodder species as feed supplements is not jointly influenced by farmer's socio-economic characteristic such as age, gender, family size, education, group membership, extension contact and land size, presence of other enterprises within the farm, milk sold and dairy cow quality (Testing the significance of the model).

H_o: β_1=β_2= β_3,……….., β_k=0

H_1: *at least one* of the β_k is nonzero

Where i=1, 2, 3………………k.This null hypothesis states as a conjecture that each and every one of the parametersβ_k, other than the intercept parameter β_0 is zero.

1.3.3 Adoption and use of Calliandra and Leuceana shrubs is not related to each of the explanatory variables (β_k).

H_o: β_k=0

H_1:$\beta_k \neq 0$

1.5 Justification of the Study

Although according to Wambugu *et al.*,(2006) the adoption of Calliandra and Leuceana species for use as dairy feed supplements was believed to be high in Kenya's densely populated highlands, the amount in the Kisii Central Sub-Countywas inexplicably small (GoK-MOLD,2006). Due to the favorable climatic conditions, relatively small land sizes and the high dairy population in Kisii Central Sub-County, it was anticipated that this technology with potential to significantly increase milk yield will easily be adopted by the smallholder dairy farmers.

However, a major question confronting both extension service providers and programmes promoting Calliandra and Leuceana shrubs in the Sub-Countywas their low adoption rate. It isdifficult to explain the gap between the many promotion activities and the small number of Calliandra and Leuceana shrubs in the Kisii Central Sub-County. This suggests that other than physical suitability, there were other social, institutional or economic factors that influenced not only the decision of their adoption but also their use as feed supplements, hence the need for this study.

Since the introduction of these shrubs in Kisii Central Sub-County20 years ago, no ex-post research has been carried out to study the influences of the various socio-economic factors on their adoption as feed supplements for dairy feeds in Kisii Central Sub-County. Therefore their level and probability of adoption and various constraints inhibiting their uptake in the Sub-County remained unknown. As such, this study was expected to produce hitherto unavailable knowledge on this area which should form a useful material for use by policy makers, agricultural researchers, livestock extension officers and other readers in general. This knowledge and understanding was also expected to catalyze dissemination and promotion efforts with the aim of improving the adoption rate and use of this technology among the smallholder dairy farmers in Kisii Central Sub-County.
According to Mercer and Miller (1998), the main reason agro-forestry technologies failed to be adopted by farmers was lack of attention to socio-economic issues in the promotion of the technologies as well as in their extension and dissemination. Although physical conditions, small land sizes and high dairy densities necessary for adoption of this technology are available in Kisii Central Sub-County, it was evident they were not by themselves sufficient to guarantee adoption of this technology among the small holder dairy farmers.

This is because physical suitability like climates and dairy densities alone cannot always predict the likelihood of adoption since adoption is also a function of the socio-economic factors whose influence is unknown in the Sub-County. The factors influencing adoption are also very complex and it is therefore essential to have detailed knowledge of the location specific socio- economic factors and how they interact to influence adoption decisions by the smallholder dairy farmers in the Kisii Central Sub-County.

It is on this strength that a study on these factors as they influence adoption among the smallholder dairy farmers in the Sub-County was deemed necessary. This study will contribute valuable knowledge to the field of livestock and agricultural technology adoption in general. This knowledge will enrich information already available and will improve the promotion approach currently being used by the livestock extension service providers and the researchers in the Kisii Central Sub-County as well as in other areas with similar socio-economic characteristics.

Understanding the factors influencing the adoption process of Calliandra and Leuceana shrubs among the small holder dairy farmers in the Sub-County is also crucial at this stage for promoting dissemination and adoption efforts especially among the many Dairy Common Interest Groups (CIGs) being formed under the on-going National Agriculture and Livestock Extension Programme (NALEP)-Sida and the Small Holder Dairy Commercialization Project (SDCP).

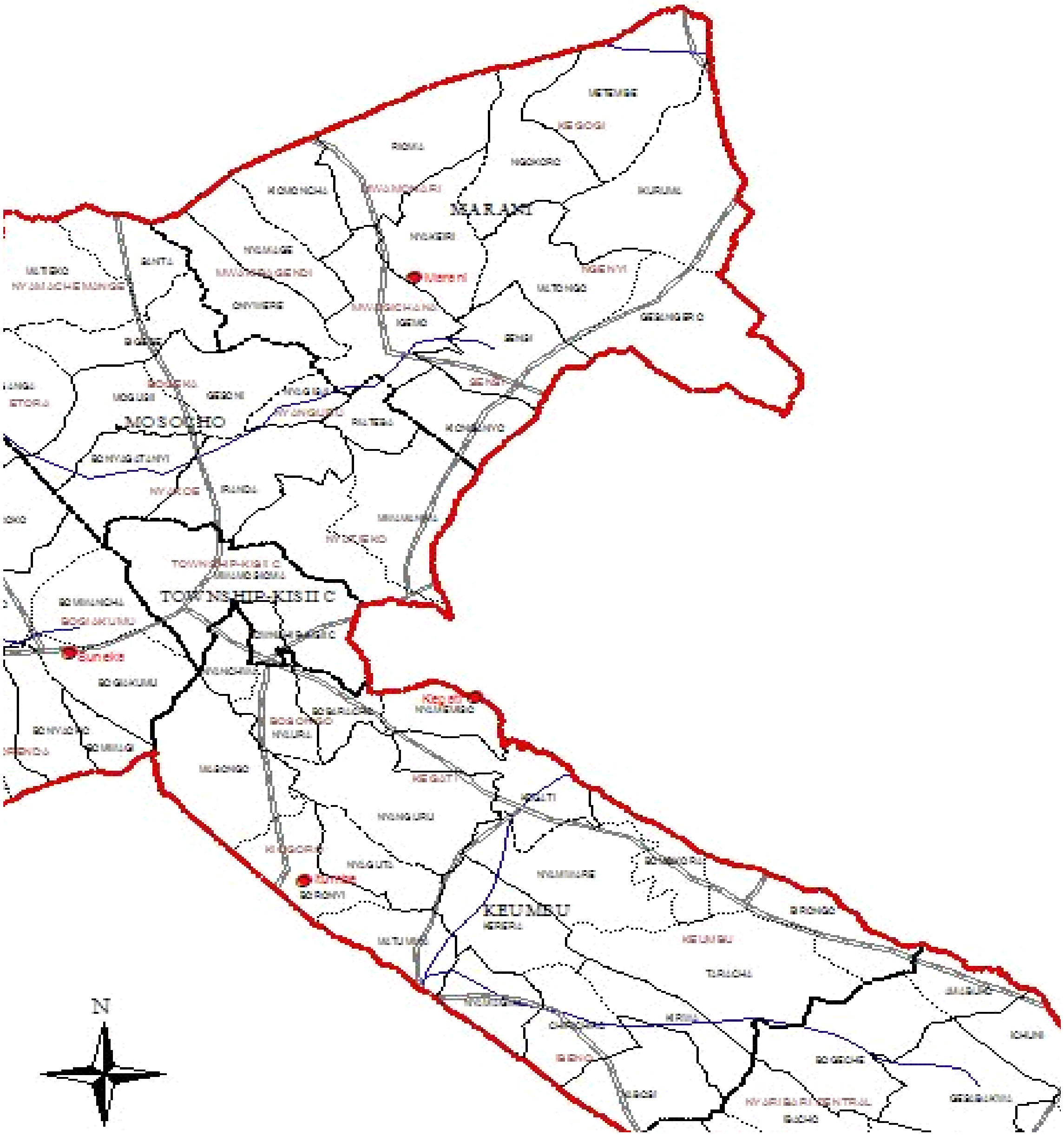
1.6 The Study Area

The study was carried out in Kisii Central Sub-County in Nyanza Provinceof theRepublic of Kenya. Kisii Central Sub-Countymeasures approximately 362.6 km^2, with a total population of 365,745(Gok, 2009). It has four Wards namely:-Kiogoro and Keumbu to the east of Kisii Town and Marani and Mosocho to the west. It has 18 administrative locations with 46 sub-locations. It has an altitude ranging 1420-2200 metres above sea level with a bimodal rainfall pattern.

The annual rainfall range between 1200 and 2400mm and three agro- ecological zones namely; LH_1, LH_2, UM_1 and LM_1.The Sub-County was selected because it is a high potential area and the climatic conditions were favorably forCalliandra and Leuceanaspecies. According to Wambugu*etal.*, (2006), Calliandra grows best in higher rainfall areas with a short dry season.

Kisii Central Sub-County is home to the Kisii people whose dominant economic activities are crops and livestock farming. The production system in the Kisii Central Sub-Countyis mixed crops and livestock system with the main food crops being maize, bananas, beans and finger millet. The major cash enterprises include dairy, poultry, tea and horticultural crops. All these enterprises compete for the scarce land resources and the small holder farmers allocate land resources based on returns from each enterprise.

Figure 1:1 Kisii Central Sub-Counties Map



Source (Gok, 2009).

1.7 Assumptions

The following were the assumptions of the study:-

- Farmers will volunteer to freely give all the information required during the household interviews.
- Farmers will report their true experiences and that the information given will be accurate.
- The average of all the omitted variables, and any other errors made when specifying the model, is zero. Thus, the model used is, on average, correct.
- Each of the random errors is homoscedastic.

1.8 Scope of the study

This study on socio-economic factors influencing adoption of Calliandra and Leuceana shrubs as feed supplements among the small holder dairy farmers in Kisii Central Sub-County was conducted in August 2008through a survey. The study was conducted on 116 small holder dairy farmers selected from all the four administrative Wardsof Kisii Central Sub-County of Kenya with data being collected using questionnaires and interviews.

Although there are many fodder legumes used as dairy feed supplements, the study specifically dealt with Calliandra and Leuceana fodder species only. This was because these two fodder shrubs are the most commonly grown fodder shrubs in Kisii Central Sub-County. Other fodder legumes such as desmodium, lucerne, mulberry, were not covered.

The study only covered the socio-economic characteristics of the farmer. The socio-economic characteristics covered were ;farmer's age in years,gender of household head, total family size, education level of household head, farmer's membership to a farmers' association or common interest group, contact with technology promoters such as extension or research, family land size in hectares (ha),farm ownership,presence of other income generating enterprises in the farm,importance of dairy (milk) as a source of income in the household, dairy cows' quality, if fodder crop field was rented, importance of income from competing enterprises such as tea in the households, access to fodder seeds or seedlings, milk market access problems and amount of milk sold per day. Other socio-economic factors of the farmer, technical characteristics, biophysical or village characteristics were not considered in this study.

CHAPTER 2

LITERATURE REVIEW

This chapter presents detailed literature review on Calliandra and Leuceana fodder shrubs introduction and their promotion in Kisii Central Sub-County. Section 2.2 present in-depth surveys on various socio-economic factors and their influence on adoption of agricultural technologies. Empirical approaches of agricultural technology adoption studies are covered in section 2.3. Section 2.4 and 2.5 presents general theoretical framework for modeling adoption decisions and various econometric model specifications used in past adoption studies respectively.

2.1 Fodder Shrubs and their Introduction in Kisii Central Sub-County

Calliandra is a thorn less shrub or small tree, single or multi-stemmed and is usually 4-6 meters (12-20 feet) tall. It has compound leaves which are an excellent source of supplementary protein in the diet of cattle. Calliandra and Leuceana shrubs are versatile legumes which contain high levels of protein (typically 20-28% “crude protein”), the standard measure of the amount of protein in feed (Wambugu*et al.*, 2006).In a study done in Embu, Central Kenya by Tuwei*et al.*, (2002), the leaves contained about 22% crude proteins and has a very positive effect on animal production particularly milk yield of improved dairy cows and goats.

Calliandra and Leuceana shrubs provide a valuable feed supplement for dairy cows and goats, especially during the dry season. They can be managed to provide nutritious fodder from their leaves, to supplement the diets of livestock, particularly dairy cows and goats. Their leaves contain much more protein than the rest of the animals’ normal diet of grasses and crop residues and this makes them able to produce more milk. Animal fodder is the most important product of Calliandra in East Africa.

One dairy cow requires 500 Calliandra shrubs per year and they can be used either to supplement or as a substitute for commercial concentrates. It has been shown that 1kg of concentrates can be successfully replaced by 3kg of fresh Calliandra in the diet of dairy cows (Wambugu *etal.*, 2006).Just by planting a single row of shrubs all around the boundary a farmer could establish about 1000shrubs which would be enough to feed two dairy cows throughout the year in one acre of land.

Farmers who cannot afford dairy meal can use leaves from these shrubs to formulate homemade rations. For example, a mixture of maize bran and dried Calliandra and Leuceana shrubs at a ratio of 2:1 can greatly improve the nutritional level of a dairy cow. If the protein supplement is from the shrubs forage alone, it is recommended to feed 6 -10 kg of fresh leaves per cow per day (AFRENA-ECA, 1995; Wambugu *et al.*, 2006). This translates into extra income as well as extra milk for the family. Calliandra and Leuceana shrubs can also provide a range of other products and services, including soil conservation, nitrogen to make protein, stakes, fuel wood and honey.

According to Wambugu *et al.,* (2006), *Calliandra Calothyrsus* (Calliandra) and Leuceana species are the widely promoted and adopted exotic fodder shrubs in Kenya in general and in Kisii Central Sub-County in particular. They are also the most popular species for small scale agro forestry in many parts of the tropics. They were introduced in the Sub-Countyin the late 1987 for use as dairy feed supplements to the small holder dairy farmers in Kisii Central Sub-Countyand various organizations and programmes have been involved in the promotion of this technology since then (GoK-MOLD, 1990).

According to the various Kisii Sub-County livestock annual reports, among the past and present promoters of Calliandra and Leuceana species as dairy feed supplements in Kisii Central Sub-County included:-National Dairy Development Programme (NDDP-1987-1994), Livestock Development Programme (LDP – 1992-2004),Herd Health Project, National Agriculture and Livestock Extension Programme (NALEP-Sida phase I and phase II-2000-2012) and Smallholder Dairy Project (SDP-2007-2012).

Promotion work has also been done by the International Centre for Research in Agro Forestry (ICRAF), Livestock Department, KisiiCentral and Kenya Agricultural Research Institute (KARI-Kisii). With all these promotions having been done and more still being carried out, it is difficult to explain the gap between the many promotional activities and the small number of Calliandra and Leuceana shrubs in the Sub-County which currently stand at 24,550 trees(GoK-MOLD, 2012).

2.2 Socio-Economic Factors and their influence on Adoption of Agricultural Technologies

The observed choice to adopt an agricultural technology (for example Calliandra and Leuceana) is hypothesized in many studies to be the end result of socio-economic characteristics of farmers and a complex set of inter-technology preference comparisons made by farmers (Adesina & Forson, 1995). Mercer and Miller (1998) stated that one of the reasons that agro- forestry technologies fail to be adopted by the farmers was the lack of attention to socio- economic issues in the development of the technology as well as in the extension or dissemination of the technologies.

They also noted that the most important research gap identified in literature was understanding factors affecting adoption behaviors.Sanchez (1995) raised similar issues and asked for more studies that develop models to predict farmer's adoption behavior and its determinant. This study contributed to filling this gap as it undertook to determine effects of socio-economic factors on adoption of the specified animal supplements.

Studies done by Koech (2004) and Mawanda (2004), on socio-economic impact of Calliandra, found out that the use of a technology may be financiallyprofitable but farmers may fail to adopt it due to socio-economic factors confronting them. Wambugu*et al*., (2006) identified training requirement, labor and access of seeds and seedlings as the major constraints inhibiting adoption but were not exhaustive on other factors and neither did he quantify by how much these characteristics inhibit or influence adoption of Calliandra and Leuceana shrubs.

Generally, the rate of adoption of new technologies among farmers in many developing countries have been reported to be below expectation, in many cases hardly measuring up to the research efforts involved in developing these technologies or improving existing ones (Kristfanson *et al.*,1999). Some authors attribute this result to the fact that traditional research approaches neglect the "human element" in farming systems (Norman & Baker, 1986; Walker*et al*., 1995).It has been recognized that farmers' decisions depend on and are influenced by their knowledge and perception of technology, rather than the researchers' knowledge of technology (Gladwin *et al.*, 1984; Adesina &Zinnah, 1993).

Studies of the factors influencing adoption of agricultural technologies are typically undertaken at the farm level. They focus on the household resource endowments, characteristics of the household head, location of the household, the nature and extent of information provided before adoption and the characteristics of the technology (Feber & Umah, 1993).

Most adoption studies carried out in Africa by researchers such as Attah-Krah&Francis, (1987), Tonye*et al*., (1993), Franzel, (1999) and Adesina*et al.*, (2000) on agro- forestry technologies have shown that the characteristics of the farmer are often the most significant in influencing the adoption of technologies. They include the operator's age, family size, and information variables such as contact with agencies that promote the technology, land tenure or ownership among others.

Empirical household level studies of the determinant of adoption usually find that variables such as level of education, farm size, income and land tenure have a significant impact on adoption intensity (Kristjanson *et al.*, 2002). Other variables are market access, population density and frequency of visits by village extension officers. Norris and Batie, (1987), suggested in their studies that information variables such as contact with the agencies that can educate about the technology significantly influence adoption.
The question of how much such factors influence adoption of Calliandra and Leuceanafodder shrubs in the Sub-County needed to be known and ascertained for proper and tailor-made policies to be formulated. Here below is a detailed literature review of some of themain exogenousvariables used in the specified model in this research.
On the land factor Lynne*et al.*, (1988), found that renters displayed less adoption effort of agro-forestry technologies than owners did. This means some aspects of the farming system in the sub-County need to be well understood by the technology promoters since they can sometimes make Calliandra and Leuceana shrubs establishment difficult or

impossible. An example is lack of tenure security since the farmer may not be willing to adopt or manage fodder shrubs to which other people will later have access.

There is need for proper understanding of the land factor in the adoption process of this technology in the Sub-Countysince lack of secure land tenure in some sites such as Ethiopia (Okumu, 2000), tenant farmers in Rwanda (Clay *et al.*,1998) has also been found to negatively influence adoption decisions.

According to Ministry of Agriculture (MOA) annual report for Kisii Sub-County, high population densities of 845persons per km^2 prevail. There is acute land pressure resulting in small land sizes (less than 0.6 ha). The various farm enterprises there-fore compete for the scarce land resources and the small holder farmers allocate land resources depending on returns (GoK-MOA, 2006).

Due to smaller land holdings, small holders are expected to grow high yielding fodder crops like Calliandra and Leuceana to feed the animals from an ever decreasing land area. Some studies have suggested that fodder shrubs farming should be targeted to areas with high population density (Wambugu *et al*., 2006). Whether these small land holdings act as an incentive or disincentives to adoption ofCalliandra and Leuceana was one of the main concerns of this research.

Studies on labour resource have shown that improved low input livestock management technologies are recognized as key ways of improving and sustaining productivity among small scale livestock farmers in Africa (McIntire *et al.*, 1992; Smith *et al*., 1997). However, there are few technologies available that achieve this goal without involving purchased inputs and increased labor outlays beyond the reach of most small holder households.

The result according to Sanders*et al*., (1996), is the depressingly low adoption rates for new agricultural technologies seen throughout Africa. Labor constraints are critical in farmer's use of agro forestry technology (Dvorak, 1996; Franzel, 1999). According to Wambugu *et al.*, (2006), Calliandra and Leuceana shrubs established for use as dairy feed supplements are labor intensive. Labor intensive technologies have been shown in many studies to discourage farmers from using or adopting the technology.

Therefore family size, a proxy to labour availability may positively influence the adoption of Calliandra and Leuceana shrubs technology as its availability reduces the labour constraints faced in fodder shrubs production and utilization. Ndlovu*et al*., (1996),found intheir study that methods that reduce labor intensity could enhance the adoption of livestock intensification technologies and thus improve livestock productivity.Place*et al.,* (2002) also found out that the size of the family labor endowment was positively linked to the probability or level of adoption of certain natural resource technologies.

But contrary evidence also exist that farmers find ways to accommodate practices that generate very high returns, no matter what the size of their family. At lower levels in Ethiopia, studies have shown that small households have adopted stone terraces (Gebremedhin & Swinton, 2000). Small households were also shown to adopt conservation techniques in Burkina Faso by investing during the dry season (Shapiro, 1990).These two study findings are contrary and the one applicable to Kisii situation in relation to adoption of Calliandra and Leuceana shrubs as dairy feed supplements need to be isolated.

On farm enterprise returns and competing enterprises, a study done in Ethiopia by Gebremedhinand Swinton, (2000), recommended investment in farm technologies that generate better returns in the short run. According to Place *et al.,* (2002), farmers commonly find ways to accommodate new technologies into their farming systems when incentives are sufficiently high. The question that arises here is; are there sufficiently high incentives to make small holder dairy farmers accommodate this technology in their farming system?

According to Wambugu *et al*., (2006), the allocation of resources to different activities in the farm and the opportunity costs of using Calliandra and Leuceana shrubs as dairy supplements should be well understood by both the technology promoters and the farmers since they may in some cases lead to farmers rejecting the technology. This could be the case if the dairy enterprise is not an important activity in the farm, and or labor is a limiting factor since the various farm enterprises compete for the scarce land, labor and other production resources and the smallholder farmers allocate resources depending on returns.

In such a situation where the dairy enterprise is not an important activity or there is a better farm income generating enterprise competing for the same scarce resources,Calliandra and Leuceana shrubs may not be an attractive option and can lead to reduced demand for this technology. The suitability of fodder shrubs for a particular area is therefore largely determined by the farming systems and the potential for farmers to benefit which in turn depends critically on the market access and hence, all these and many other factors needed to be assessed locally.

Market access factors refer to the existence of local markets offering good sales opportunities and adequate transport facilities**.** According to Teklewold *et al*., (2006), farmers located in villages close to towns are better able to capture economic benefits from the use of the technology than those distant from towns. This according to the researchers is due to better market access which encourages “market driven” intensification process. Adesina *et al*., (1997), was of the opinion that market access is significant and positively related to adoption decision.

According to the Kisii Sub-County livestock annual report, there is no formal system of milk marketing in the sub-County and farmers sold their milk through hawking, delivering to individual consumers, institutions and hotels (Gok-MOLD, 2006). Lack of a well-structured milk marketing system can be a disincentive to dairy intensification including the adoption of Calliandra and Leuceana for use as dairy supplements. How do market access for milk and its products influence adoption decisions for Calliandra and Leuceana shrubs among the small holder dairy farmers in Kisii Central Sub-County?

On gender and its influence on agricultural technology adoption**,** Place*et al*., (2002), premised that improved agro- forestry technologies such as fodder shrubs technologies more generally fail to be adopted by women farmers at the same rate as male farmers. The researcher observed that this could be because male farmers enjoy greater wealth, education and socio-economic power. In their study, Adesina *et al.*, (1997) found that alley farming in Nigeria was more likely to be adopted by males than by females, echoing findings with respect to fertilizer in Kenya and Rwanda (Clay*etal*., 1998).

These researchers concluded that this was because of cultural and ethnic practices which placedfemale farmers at a disadvantaged position. While conducting related study on use and adaptation of alley farming in Nigeria, Adesina and Chianu, (1997) pointed out thatgender was significant and positively related to adoption decision. The researchers reported that women may face constraints in using agro- forestry technologies. Could there be some gender biases which placed female house heads in the Kisii Central Sub-County at a disadvantaged position when it comes to making adoption decisions of this technology?

Education augments one's ability to receive, decode and understand information relevant to making innovative decisions (Wozniak, 1984). This acts as an incentive to acquire more information. Farmers with more education should be aware of more sources of information, and be more efficient in evaluating and interpreting information about innovations than those with less education (Teklewold *et al.*, 2006).

Accordingly, fodder trees farming and management is knowledge and management intensive technology in requiring ability to manage the hedgerows properly to achieve optimal results. Lack of proper understanding of the technology can lead to poor trees performance and abandonment of the fodder tree hedges. Since this technology is training intensive, was there a relationship between education level of the house hold head and its adoption level?

According to Attah-Krahand Francis, (1987), agro- forestry extension agencies have higher success rates on adoption when working with farmers groups. Versteeg and

Koudokpon, (1993), reached similar findings while studying participative farmers testing of four low external input technologies in Mono Province of Benin.

Mose*et al.*, (2000), was of the opinion that farmers who had membership to an organization tended to adopt most technological components in the use of organic and inorganic fertilizers in the North Rift Valley region of Kenya. How this influences adoption of exotic fodder shrubs decisions in Kisii Sub-County needed to be investigated. On the role of agricultural extension on adoption, Wozniak, (1984), stated that in the world of less than perfect information, the introduction of new technologies creates a demand for information useful in making adoption decisions. When it comes to analyzing the adoption decisions, agricultural extension is the most important of the many sources of information available to farmers (Teklewold*et al*., 2006).

Based on the innovation-diffusion literature it is hypothesized that extension visits are positively related to adoption by exposing farmers to new information and technical skills about planting, harvesting and dairy feeding (Adesina & Forson, 1995). Therefore frequency of interaction between the small holder dairy farmers with the technology promoters and developers is positively related to adoption.

Adesina *et al*., (1997), points that contact with technology promoters is significant and positively related to adoption decisions. This is because contact with extension agents allows farmers to be able to get information on the technology and possibly see or participate in demonstrations. Agricultural extension may also enhance the efficiency of making adoption decisions.

While studying farmers' perception and adoption of new agricultural technologies, Adesina and Forson, (1995), indicated that the expected result of age is an empirical question. According to the researchers, older farmers may be more risk averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting new technologies.

However, it could also be that older farmers have more experience in farming and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher probability of adopting the practice. There is therefore no agreement in the adoption literature on this as the direction of the effect is generally location or technology specific. The Kisii Central Sub-Countysituation was to be empirically answered through this study.

The qualities of the dairy cow breed have also been shown in some studies to affect adoption of livestock technologies. Farmers are highly likely to be motivated to plant fodder trees if they have good quality or improved dairy cows (Wambugu*etal*., 2006). These dairy cows have a much greater potential for milk production than local or poor crosses, hence improved dairy breeds can act as an incentive to adoption of fodder shrubs.

The decision to adopt any single innovation depends on the availability of inputs (Wozniak, 1984). In this case, seeds and seedlings are the most critical input. Seeds accessibility may influence adoption decisions in that lack of seeds or seedlings or their inaccessibility by the smallholder dairy farmers may inhibit adoption decisions.

According toBarret*et al.,* (2002), most technology adoption studies have handled the farmers-user (demand) side reasonably well. Most studies provide careful detailed descriptions of how and why farmers are motivated to adopt agricultural or natural resource practices. But the supply-side issues such as the role of extension service, researchers or technology promoters in general information flow are increasingly recognized as important, but remain understudied.

As a result, the flow of information to and awareness of farmers and other natural resource users is highly variable in covering, timing and quality/reliability, so the ‘supply side’ of a technology is also important for explaining observed adoption patterns. However, since this aspect has received far less systematic attention according to these researchers, there was great need to capture and highlight these issues in this study.

This study therefore attempted to bridge this gap by handling both the farmer-user (demand) side and supply side issues since the adoption of agricultural practices in general results from interaction between providers of information and farmers decision makers who act upon the information.

2.3 Empirical Approaches of Agricultural Technology Adoption Studies

According to Adesina and Zinnah, (1993), adoption literature falls into three groups of paradigms for explaining adoption decisions. They involve: the innovation diffusion model that holds that access to information about an innovation is the key factor determining the adoption decisions; the economic constraint model which holds that resource endowment like capital and land are the major determinants of adoption behaviour and; the adopter perception paradigm that suggests that the perceived attributes of an innovation influences adoption behavior (Mutai *etal*., 2007).

This study adopted the economic constraint model that is in line with the broad objective which was to determine the socio-economic factors that significantly influence smallholder dairy farmer’s adoption of Calliandra and Leuceana shrubs as dairy supplements. This was in line with Mercer and Miller, (1998), who suggested that the main reason agro-forestry technologies fail to be adopted by farmers is due to lack of attention to various socio-economic issues affecting them.

Griliches, (1957), examined the determinants of diffusion of hybrid corn in the Midwestern states in the United States of America. He found that the rate of adoption is an increasing S-shaped function of time during which the new innovation has been available. The exact shape of the function is determined by crop profitability and other economic variables. His seminal work paved the way for most of the current empirical literature on technology adoption including this current work.

According to Liu, (2007), technology adoption is a difficult subject to study because so many determinants are un-observable. There is therefore the need for applied economists to scrutinize many of the possible determinants so that finally a better understanding of the underlying mechanism can be obtained. The importance of examining socio-economic determinants of Calliandra and Leuceana adoption at this stage could therefore not be over-emphasized.

In their study, Foster and Rosenzweig, (1996), stated that farmers with more experienced neighbours have higher profits than those without. Conley and Udry, (2003), examined further the role of communication and social learning in technology adoption and they distinguished information neighbors from geographical neighbors. They constructed a detailed information network map among pineapple farmers in a village in Ghana. They found evidence that farmers imitate the choices of their information neighbours when this neighbours experiences a fruitful year in agricultural production. It is likely that farmers hold beliefs about the benefits of Calliandra and Leuceana fodder shrubs prior to their adoption, and they update their beliefs as they receive new information about these shrubs from other fodder shrubs adopters.

Many researchers have also looked at the role of credit constraints in adoption decisions. They include Mutai*et al.,* (2007), Teklewold *et al.*, (2006), Suri, (2005) and Croppenstedt *et al.,* (2003). In their study Croppenstedt*et al.,* (2003), estimated a model of fertilizer adoption in Ethiopia. Their findings suggested that household cash resources are generally insufficient to cover fertilizer purchases hence the need for credit accessibility to foster fertilizer adoption.

Suri, (2006), tried to explain why farmers switch in and out of adoption of hybrid maize and fertilizer in Kenya. She concluded that providing credit can only benefit a small fraction of Kenyan farmers. Neither constraints nor irrationalities can explain the stagnation of hybrid maize adoption. However, credit constraints were less likely to apply in this research because the decision to adopt exotic fodder shrubs only increases total investment costs by a marginal amount.

Some researchers have also looked at the role of risks as a constraint in adoption decisions. They included Knight*et al.,* (2003) and Liu, (2007). Liu (2007) studied the technology adoption of Chinese cotton farmers. The researcher found that risk aversion was associated with lower probabilities of technology adoption. This study however, concentrated on identifying those social-economic factors hindering the adoption of Calliandra and Leuceana fodder shrubs by the smallholder dairy farmers in Kisii Central Sub-County.

A lot of Research work has been done on how farmers' perception of the technology characteristics affects their adoption decisions but little work has been done on how the market and the farmer's perception of the market affect adoption. Testing the hypothesis that farmers' perception of the technology characteristics significantly affects their adoption decisions Adesina and Baidu, (1995), used Tobit model in their study on farmer's perception and adoption of modern sorghum in Burkina Faso and improved mangrove swamp rice varieties in Guinea. The farmer's knowledge and perception of the technology was positively related to the probability of adoption and intensity of cultivation of the improved sorghum varieties.

But according to Mutai *etal.*, (2007), adoption literature in Kenya does not show clearly how the market and the farmers' perception of the market affect adoption in the first instance. Also farmers have certain expectations when adopting specific technology which if not met can cause farmers to abandon the use of such technology. This study while not focusing on farmer's perception of the technology under study tried to find out how the milk market and farmers perception of the market among other factors affected adoption of Calliandra and Leuceana fodder shrubs that are used as dairy supplements.

2.4 General Theoretical Framework for ModelingAdoption Decisions

To model farmers' adoption decisions, farmers' welfare or utility, maximization was used. Maximization frame work has been used in a number of studies (Norris & Batie, 1987;

Adesina & Zinnah, 1993; Adesina & Forson, 1995; Adesina & Chianu, 2002;and Teklewold *et al.*, 2006).The theoretical framework adopted by theseresearchers was thatfarmers were assumed to maximize expected utility according to a von Neuman Morgenstern utility function defined over wealth (W).

According to Teklewold *et al.*, (2006), when confronted with a choice between two alternative practices, the i^{th} farmer compares the expected utility with the modern technology, EU_{mi} (W) to the expected utility with the traditional technology, EU_{ti}(W).Given the usual discrete choice analysis and limiting the amount of non-linearity in the likelihood function, EU_{mi} (W) and EU_{ti}(W) were written as:

$EU_{mi}(W) = \alpha_m X_i + \varepsilon_{mi}$-- (2.1)

$EU_{ti}(W) = \alpha_t X_i + \varepsilon_{ti}$--(2.2)

The difference in expected utility was then written as:

$EU_{mi}(W) - EU_{ti}(W) = (\alpha_m X_i + \varepsilon_{mi}) - (\alpha_t X_i + \varepsilon_{ti}) = (\alpha_m - \alpha_t) X_i + (\varepsilon_{mi} - \varepsilon_{ti})$

$= \alpha Xi + \varepsilon i$--- (2.3)

According to the researcher, preference for the modern technology will then result if:

$EU_{mi}(W) - EU_{ti}(W) > 0$; ---(2.4)

Whereas, a preference for the traditional technology will be revealed if:

$EU_{mi}(W) - EU_{ti}(W) < 0$---(2.5)

Where X_i is the matrix of explanatory variables related to the adoption of technology by the *i*th farmer; αis the parameter to be estimated and $\varepsilon_i$is the random error term. The current study adopted the same theoretical framework since it permitted the investigation of the decision whether or not to adopt exotic fodder shrubs and the conditional level of the technology if the initial adoption decision was made.

2.5 A Survey of EconometricModel Specifiedfor Use in Adoption Studies

Most researchers of adoption studies specify discrete choice models of Tobit, Logitor Probitdistributions where the interest is in examining the role of farm and operator characteristics affecting adoption decisions. Jansen *et al.*, (1990) while assessing the concept of evidence for regional adoption ceilings for modern coarse cereal cultivars

used a logistic equation of the form;F_i (t) =. $\frac{1+\exp(-a-b_i t) ¿ Yi}{¿}$ Where F_i (t) is the cumulative percentage area sown with modern cultivars for production region *i* and time *t*. Y is the ceiling coefficient, *b* is the diffusion speed coefficient and *a* is a constant of integration that positions the curve on the time scale.

Adesina & Chianu, (2002) also used a Logit model to determine the socio- economic factors that influenced farmers' adoption and modification of the alley- farming technology in Nigeria. The Logit model the researcher used was specified as:

$$Y_{ik} = F(I_{ik}) = \frac{e^{Z_{ik}}}{1+e^{Z_{ik}}}, \quad \text{where } Z_{ik} = X_{ik}\beta_{ik} \text{ and } -\infty < Z_{ik} <+¿ \infty \text{………………………………}(2.6)$$

Where Z_{ik} was the dependent variable which took the value of 1 for the *i*th farmer that had adopted alley cropping in zone k and *0* if no adoption occurred.X_{ik} was the matrix of explanatory variables related to the adoption of alley cropping by the *i*th farmer in zone k, and $\beta_{ik}$was the vector of parameters to be estimated. I_{ik} was an implicit variable that indexes adoption. The researcher estimated the Logit model by maximum-likelihood method using LIMDEP 6.0©.

Mutai*et al*., (2007), alsoapplied the Logit model to analyze the factors that influence access to loans by the small holder horticultural farmers in the North Rift Region of Kenya. The estimation of Logit model on cumulative probability function used by the researcher was:P_i=P_i (Z_i) =exp (Z_i) (1+expZ_i) = (1+exp^{-zi}) ------------------------------(2.7)

Where$P_i$was the probability of benefiting from loans and hence (1-P_i) was the probability of not benefiting from loans and given by 1/ (1+exp^{zi}).P/ (1- P_i) are the ratio in favor of benefiting. The dependent variable log {P_i / (1-P_i} was the odds ratio in favor of benefit. ALogit model estimated was:

Z_i=log (P_i /1-P_i) =a_i+ $\beta_i X_i$+ui---(2.8)

Where X_i's were the dependent variables.

To evaluate adoption decisions, Tobin (1958), also proposed the use of a Tobit model. Kristjanson *et al*., (2002), used this Tobit model in evaluating adoption of new crop-livestock-soil management technologies using Geo-referenced village level data (the case of cow pea in the dry savannahs of West Africa). Oladele, (2005), specified the Tobit model in analyzing the propensity to discontinue adoption of agricultural technology among farmers in Southwest Nigeria. His work centered on maize and Soya beans technologies and the model fitted the data well.

In Ethiopia, Teklewold *et al*., (2006), conducted a study on the determinants of adoption of poultry technology using a parametric generalization of the Tobit model commonly known as the double-hurdlemodel. The double-hurdle model the researcher used had an adoption equation (D) to capture the decision on whether to adopt or not:

$D_i=1$ if $D_i^* > 0$ and 0 if $D_i^* < 0$ and $D_i = \alpha Z_i + U_i$. D^* being a latent variable that takes the value 1 if the farmer adopts exotic poultry adoption breed and zero otherwise, Z is a vector of household characteristics and α is a vector of parameters. This approach has been intensively used in adoption and impact studies (Adesina&Baidu, 1995; Sanginga*et al*., 1999and Oladele, 2005). However due to the mathematical complexity of the Tobit model and unavailability of a computer software, itcould not be the model of choice in this study. In view of the above literature review, the current study was felt necessary to be undertaken because not much has been done on Calliandra and Leuceanashrubs adoption and more so on socio-economic factors influencing their adoption for use as dairy feed supplements among small holder dairy farmers.

2.6 Conceptual Frame Work

The conceptual framework used for this studyis presented in the figure 2.1 below:

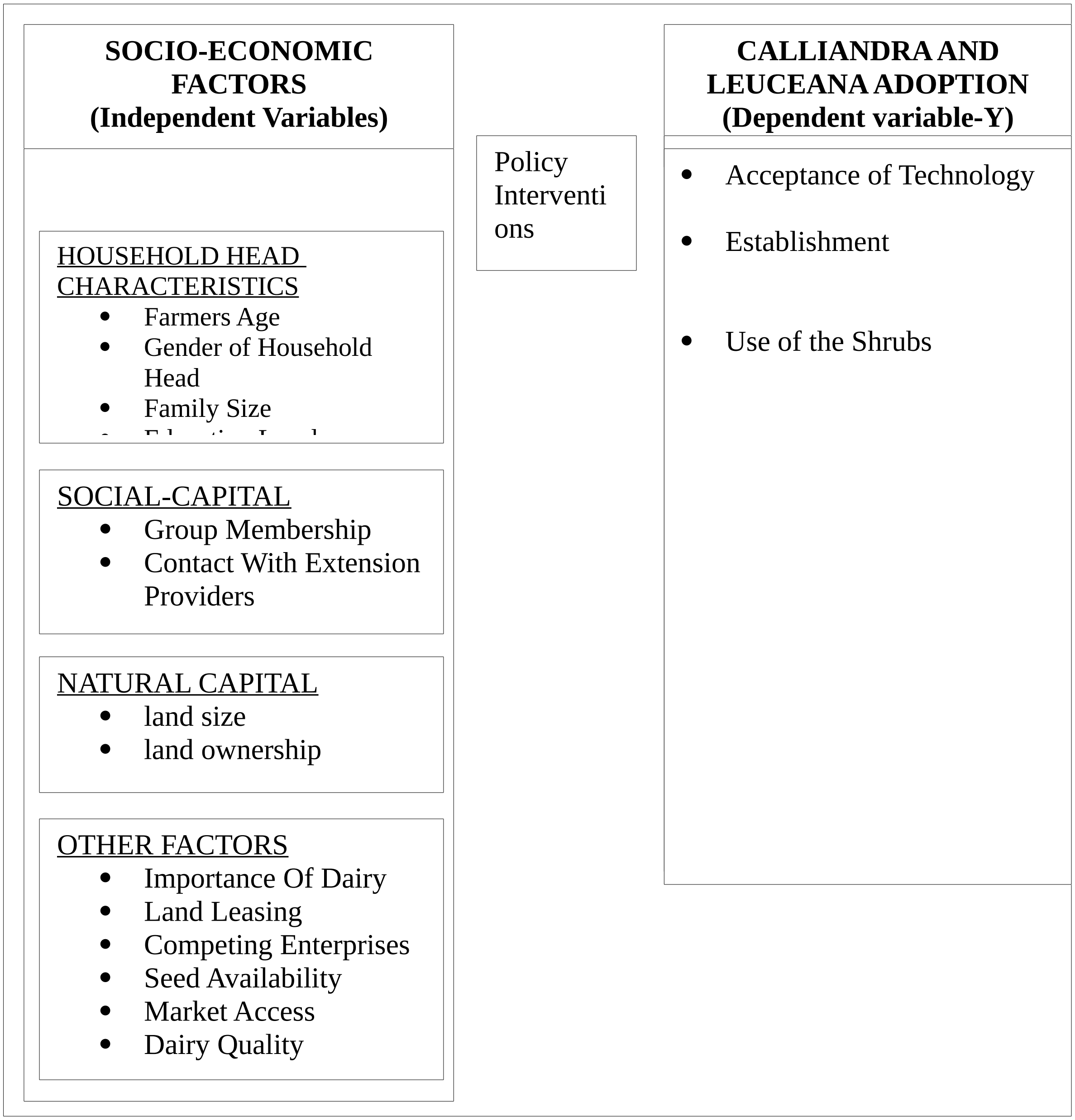


Figure: 2.1TheConceptual Frame Work

In the conceptual framework depicted in figure: 2.1 above, socio-economic factors are hypothesized to influence adoption of Calliandra and Leuceanaspecies for use as dairy feed supplements. Socio-economic factors are defined as household head characteristics, social capital, natural capital and other related factors.Calliandra and Leuceana adoption is defined as the acceptance, establishment and use of these fodder species as dairy feed supplements by the small holder dairy farmers in Kisii Central Sub-County.

The frame work postulates that the status of farmer's, gender, family size, education level, membership to farmers groups, contact with extension agents, land ownership and dairy cow quality and seed availability was expected to positively affect the acceptance, establishment and use of Calliandra and Leuceana species as dairy feed supplements. Whereas land size, landleasing, existence of market problem and presence of competing enterprises within the farm were expected to negatively influence adoption. However, the relationship between farmer's age and adoption was expected to be either positive or negative.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter presents a detailed description of research methodology used in this study. It covers a description of research design employed by the researcher, sampling and data collection methods, methods of data analysis used, theoretical frame-work, model specified for data analysis in this study, hypothesis testing and inference and a detailed description of variables in the specified econometric modelapriori.

3.1 Research Design

This study was conducted through descriptive survey design in which data was generally drawn in a cross- sectional setting from target households. A cross section is a sample of a number of observational units all drawn at the same point in time (Greene, 1993). Both primary and secondary data was utilized. The Secondary data was mainly sourced from the Ministry of Livestock Developmentreports existing within theKisii Central Sub-County and from published books while primary data was obtained using questionnaires and focused household interviews in the field.

3.2 The Study Population

This study mainly focused on160 practicing small-scale dairy farmers from Kinyambi, Gichochi, Ititi and Sasuri villages within the four Wardsof Kisii Central Sub-County namely Keumbu, Kiogoro, Mosocho and Marani. The selected farmers comprised both the adopters and non-adopting dairy farmers.

3.3 Sample and Sampling Method

Mugenda and Mugenda, (1999), suggest two methods of determining sample size in social science studies. For descriptive studies a sample size of ten percent of the accessible population is adequate. However, for a more accurate calculation of the sample size, the following formula was used as suggested by the author;

$$nf = \frac{n}{(1 + n/N)}$$

Where:

nf=the desired sample size when the population is less than 10,000, n= the desired sample size when the population is more than 10,000 and which is given by 384, N =the estimate of the target population size. The formula stated above was used to calculate the sample size as shown below:

$$nf = \frac{n}{(1 + n/N)} = nf = \frac{384}{(1 + 384/160)} = nf = \frac{384}{3.4} = 113$$

Therefore with an estimate of the target population of 160 smallholder dairy farmers, a sample size of at least 113 respondents was appropriate.

Since the rule of thumb is to obtain as big a sample as possible while also keeping in view the time and resource constraints, a sample of 116 small scale dairy farmers were selected from the target population using simple random sampling and stratified sampling and later on interviewed to collect the necessary data. A sample of n observations on one or more variables, denoted $X_1, X_2, \ldots\ldots, X_n$is a random sample if the *n* observations are drawn independently from the same population, or probability distribution ,$f(X_i,\theta)$ (Greene, 1993).

At the Ward level, survey villages were selected randomly and thereafter, since the interest was on the practicing small holder dairy farmers, a list of all the small holder dairy farmers in the village was developed. From this initial list, the farmers were then stratified by gender strata such that four homogenous subgroups were identified, namely; male adopters, female adopters, male non- adopters and female non-adopters. Thereafter, simple random sampling was then employed in each subgroup to select the final sample size of 116.

The respondents in each village were selected in such a way as to ensure that each homogenous subgroup were represented in the final sample in proportion to their number in the population, including female headed house hold (FHH). The sample thus obtained considered to be fairly representative of the smallholder dairy farmers in Kisii Central Sub-County. The survey covered detailed information on household characteristics, individual characteristics, fodder trees and dairy information for every household. The details on the selected villages and the number of gender stratified adopting and non-adopting respondents selected for the study is shown on Table 3.1 below.

Table: 3.1Number of Selected Respondents in Each of the Four Villages of Kisii Central Sub-County

Ward	No. of Dairy Farmers	No. of Adopters		No.of Non-Adopters		Adopters Selected		Non-Adopters Selected		Total Selected		
		M	F	M	F	M	F	M	F	M	F	Total
Keumbu	65	22	4	18	21	15	3	14	15	29	18	47
Kiogoro	55	15	2	17	21	11	1	12	16	23	17	40
Mosocho	19	6	0	7	6	3	0	5	6	8	6	14
Marani	21	4	1	7	9	3	0	6	6	9	6	15
Total	**160**	**47**	**7**	**49**	**57**	**32**	**4**	**37**	**43**	**69**	**47**	**116**

Source: Field Survey, August2008(M=Male=Female). From the 116 sampled farmers, 36 were adopters and 80 were non-adopters.

3.4 Data Collection

An initial sample of 10 farmers (dairy) from outside the study area was used to pilot the instruments, refine the adoption model and to pre-test the questionnaires for validity, reliability and further improvement. After pre-testing the questionnaires, the head of the household was the one who was interviewed but when the head of the household was doing off-farm work or was absent, the family member who was the most responsible for farm work was interviewed.

The respondents were practicing smallholder dairy farmers from four villages within Kisii Central Sub-County and information was collected from them using questionnaires and household interviews. The focus was on socio-economic factors affecting their decision to adopt Calliandra and Leuceana shrubs for use as supplements in their dairy rations. The selection of these tools was guided by the nature of data required as well as the objectives of the study. Questionnaires were used since the study was concerned with variables that cannot be directly observed such as views and the perceptions of the respondents.

Household interviews were used to collect primary data by use of four trained local enumerators using structured interview guides while secondary data was sourced by the researcher from official livestock reports in the Sub-Countyfor this particular study. The data were collected in August 2008 and all interviews were conducted in the Gusii language that was familiar to most respondents.

The survey covered detailed information on household characteristics, individual characteristics, fodder trees and dairy information for every household. The variables captured during the interviews include; number of fodder trees in each household, accessibility to fodder tree seeds, amount of milk sold in the target households, labour availability, presence of dairy competing enterprises, land sizes, contact or access to extension services, gender issues, data on age, education, land ownership, family size and membership to extension groups.

3.5 Methods of Data Analysis

In this study, the dependent variable (adoption) was a dummy since a household decides to adopt Calliandra or Leuceana fodder shrubs or they don't (either-or in nature). The dummy dependent variable was taking the value of 1 for adoption and 0 otherwise hence the use of a discrete choice model known as Logit. It was therefore suitable to analyze data not only by use of descriptive statistics, frequency Tables and charts but also by employing maximum likelihood estimation procedure for inferential analyses. The descriptive statistics were used to examine the socio-economic characteristics of adopters and non-adopters and involved generation of summary statistics. The inferential statistics involved use of logistic regression analysis in order to analyze the hypothesized relationship between variables. STATA 10 was used to compute and analyze the postulated relationships.

Since Logit is a binary or discrete choice model, estimation was based on the methods of maximum likelihood where each observation was treated as a single draw from a Bernoulli distribution (Greene, 1993).A simple correlation analysis was also carried out to establish how the various variables in the choice model of adoption correlated each other. This was done to examine the independent variables for multicollinearlity before the model was specified. A commonly used rule of thumb is that a correlation coefficient between two explanatory variables greater than 0.5 in absolute terms indicates a strong linear association and potentially harmful collinear relationship. The logistic analysis involved estimation of both the quantitative and qualitative variables specified in the econometric model and have been used in many adoption studies.

All data were analysed at 0.05 level significance since it is usually the most commonly used value. This level of significant ($\propto$ =0.05) means that we were 95% confident that any difference noticed was due to socio-economic characteristics of the farmers and not the result of chance.

3.7 Theoretical Frame Work

This study was modeled on randomutility – maximization theory advanced by Nakosteen-Zimmer (1980)as indicated below.

$U^a \leq U^b$=0 or $Y^* = U^a > U^b$ =1--(3.1)

The theory postulates that the individual's utility of two choices can be represented by U^a and U^b,where $U^a$was assumed to be the utility an individual derives for adopting a technology and U^b for non-adoption. The observed choice between the two revealed which one provides the greater utility. The observed indicator equals one if $U^a > U^b$ and zero if $U^a \leq U^b$.This isbecause farmers adopt what is beneficial to them such that the higher the utility of the technology, the higher the probability of adoption. This theory was also advanced by Adesina and Zinnah (1993).

As adapted in this study, the random utility – maximization theory holds that the dairy farmer's adoption of Calliandra and Leuceana technology can be based on an assumed underlying utility function. Since the farmers have an option to adopt Calliandra and Leuceana shrubs technology or any other agricultural technology, the technology of choice can be represented by j where j = 1 for Calliandra and Leuceana shrubs farming and j = 2 for non Calliandra and Leuceana shrubs farming options. The latter may include the use of conventional Napier or crop residues as livestock feed or dairy meal only. The non-observable utility function that ranks the i^{th} farmer's preference is given by:-

$U(M_{ji}, C_{ji})$ …………………………………………………………………………… (3.2)

WhereM_{ji} is the vector of farmer specific characteristics (social) by the *i*th adopting or non-adopting farmer andC_{ji} is the vector of economic factors. The underlying utility function for the farmer can then be represented as:-

$U_{ji} = \alpha_j F_i (M_{ji}, C_{ji}) + \varepsilon_{ji}$…………….. ………………………………………………… (3.3)

Where j = 1, 2= adoption or non-adoption of Calliandra and Leuceana shrubs

i = 1, 2, 3 ….n

α = parameter estimate or coefficient

ε =error term

The form of equation (3.2) can be linear or nonlinear depending on the assumed distribution of the error term, ε_{ji}. Since the utilities are random, the farmer will adopt fodder shrubs, farming if the preference comparison is such that:-

$U1_i > U2_i$ or $Y^* = U1_i - U2_i > 0$……………………………………………... (3.4)

Otherwise, he will not adopt. Where Y* is the non-observable (latent) random variable. Hence, following Adesina and Chianu (2002), the probability of adoption of Calliandra and Leuceana shrubs can then be represented by the equation below:

$P_i = \Pr(Y_i=1) = \Pr(U1_i > U2_i) = \Pr\{(\alpha 1)F_i(M1_i, C1_i) + \varepsilon 1_i > (\alpha 2)F_i(M2_i, C2_i) + \varepsilon 2_i\}$

$= \Pr\{(\varepsilon 1_i - \varepsilon 2_i) > F_i(M_i, C_i)(\alpha 2 - \alpha 1)\} = \Pr\{u_i > -F_i(M_i, C_i, \beta\} = F_i(X_i \beta)$ or $Y_i(X_i\beta)$……....(3.5)

Where X_i is then x k matrix of explanatory variables and β is kx1 vector of parameters to be estimated; u_i is the random error term and $Y_i(X_i \beta)$ is the cumulative distribution function for u_i estimated at $X_i \beta$.

Accordingly, the probability that a farmer will adopt exotic fodder shrubs for use as dairy feed supplements is thus a function of the explanatory variables and the unknown error term. To estimate $Y_i$requires that one specifies the nature of the distribution of the error term which can be Probit, Logistic or Tobit.

If it is assumed that the error term follows a normal distribution, then Y_i can be estimated using a Probit model which assumes a Probit distribution. In this study, the error term was assumed to follow a logistic distribution which means a Logit model was specified for estimation of Y_i.

3.7 Empirical Model Specification for Inferential Statistics -The Logit

Due to its numerous mathematical advantages and availability of computer programmes compared to other discrete choice models, the Logit model was used for inferential analysis in this study following Gujarati and Dormar (1995), and Sharma (1997). The use of Logitmodel, which gives the maximum likelihood estimates overcomes most of the problems associated with ordinary least squares and linear probability models(LPM) since it provided parameter estimators which are asymptotically consistent, efficient and Gaussian so that the analogue of the regression t-test can be applied.

The adoption model used is as specified below:

$Y_i = F(Z_i)$ and

$$Z_i = \alpha + \sum_{j=1}^{n} B_j X_{ji}$$

Where, $Y_i = the\, observed$ response of the i-th farmer (i.e. the binary variable, Y_i =1 for an adopter, Y_i =0 for a non-adopter). Z_i =an underlying and un-observed stimulus index for the i-th farmer (when Z_i exceeds some threshold level ($Z^{¿}$), the farmer is observed to be an adopter, otherwise he is a non-adopter when Z_i falls below the threshold value).

$F = ¿$ Functional relationship between field observation (Y_i) and the stimulus index (Z_i) which determines the probability of technology adoption.

i =1, 2… m, are observations on variables for the adoption model, m being the sample size (116).

J=1, 2… n, where n, is the total number of explanatory variables (16), α is constant and B_{js} are the unknown parameters.

The Logit model also guarantees that the estimated probabilities lie in the 0-1 range and that they are nonlinearly related to the explanatory variables (Gujarati, 1995). This model is based on cumulative logistic probability function and was specified as:

$$P_i = F(Z_i) \quad ¿\, F[\alpha + \sum_{j=1}^{n} B_j X_{ji}]$$

$$¿\, \frac{1}{1+e^{-Z}}$$

$$¿\, \frac{1}{1+e^{(-\alpha+\sum_{i=0}^{n} B_j X_{ji})}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(3.6)

Where **e** represents the base of natural logarithms, p_i is the probability that an individual will make a certain choice, given knowledge of X_{ji}.

The Logit model assumes that the underlying and unobserved stimulus index **(**Z_i**),** also called the Logit (***L***) is a random variable which predicts the probability of adoption of fodder shrubs for use as dairy feed supplements (when $Z_i$exceeds some threshold level (Z^*), the farmer is observed to be an adopter; otherwise he is a non-adopter when it falls below the threshold level).

$$P_i = \frac{\exp^{Z_i}}{1+\exp^{Z_i}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(3.7)

Hence, if P_i ,the probability of adopting Calliandra and Leuceana as dairy feed supplements, is given by equation (3.6), then, the probability of not adopting Calliandra and Leuceana as dairy feed supplements, is ($1-P_i$) and is given by:

$$1-P_i=1+\exp^{Z_i} \quad \text{……………………………………… ……………………. (3.8)}$$

This can also be written as:

$$\frac{P_i}{(1-P_i)}=\frac{1+e^{Z_i}}{1+e^{-Z_i}}=e^{Z_i} \quad \text{………………………………………………………………………………}$$

(3.9)

Hence, ($\frac{P_i}{(1-P_i)}$) is called the odds ratio in favour of adoption of Calliandra and Leuceana as dairy feed supplements. Now, taking the natural log of equation (3.9), the result for an individual farmer was given by the equation:

$$L_i = 1n\left(\frac{P_i}{(1-P_i)}\right) = Z_i$$

$$¿\alpha+\sum_{j=1}^{n} B_j X_{ji}$$

$$= \alpha+¿ \; B_1 X_1+B_2X_2+B_3X_3 \text{ ………………………..}+ B_nX_n+\mu \text{…………………………(3.10)}$$

Where Lis the log of odds ratio (Logit) and is not only linear in X, but also (from the estimation view point) linear in the parameters which was very crucial in this study. This is the Logit model (Gujarat, 1995).

The interpretation of the Logit model is as follows: B_i the slope, measures the change in L for a unit change in X_i, that is it tells how the log-odds in favor of adopting fodder shrubs as dairy feed supplements changes as X_i changes by a unit. The intercept α , is the value of the log-odds in favor of adoption of Calliandra and Leuceana if all explanatory variables are zero. In this model, as in many others, the intercept was included in the model for mathematical completeness and to improve the model's predictive ability (Hill et al., 2002).

The Logit function was therefore chosen for this study because of the following other desirable features (Gujarati, 1995):

i) As *P* goes from 0 to 1 (i.e., as Z varies from -∞ to +∞), the Logit *L* goes from -∞ to +∞. That is, although the probabilities (of necessity) lie between 0 and 1, the logits are not so bound.

ii) Although *L* is linear in X_i, the probabilities themselves are not. This property ensures the probabilities do not increase linearly with X_i..

iii) The Logit model assumes that the log of odds ratio is linearly related to X_i.

3.8 The Marginal Effect of a Unit Change in the Value of a Regressor

The relative effect of each explanatory variable X_i on the probability of adoption of technology is measured by differentiating $P_i = \frac{\exp^{Z_i}}{1+\exp^{Z_i}}$ with respect to X_{ji}, i.e.,$\delta p_j / \delta x_{ji}$ and using quotient rule:

$$\frac{\delta P_i}{\delta X_{ji}} = \frac{B_i \exp^{Z_i}}{\left(1+\exp^{Z_i}\right)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(3.11)

Where P_i is the probability of occurrence of the dependent variable, and X_{ji} is the vector of explanatory variables (Sharma, 1997).Accordingly, the predicted changes in the probabilities of adopting of fodder shrubs for use as dairy feeds supplements can be used to estimate the change in the number of farmers adopting fodder shrubs for use as dairy feeds supplements.

3.8 Description of Variables in the Specified Econometric Model

The dependent variable (Z) used in the specified Logit model is a binary variable regarding the adoption of Calliandra and Leuceana fodder shrubs as dairy feed supplements. The variable was assigned the value of one if the household had planted either Calliandra, Leuceana or both fodder shrubs and a value of zero otherwise (0, 1).

The independent variables comprised human, social, natural and biophysical capital and market access factors. Under human capital, the variables included farmer' age, gender, family size and education level. Farmer's age (AGEHH**)** may influence both the decision to adopt and extent of adoption of Calliandra and Leuceana shrubs.

The direction of the effect of age on adoption decisions is generally location or technology specific and in this study, the expected result of age was to be answered empirically. The farmer's age was obtained by asking the respondent the age of the household head or farm operator.

Detailed definitions of all variables in the survey and which was used in the specified econometric model are summarized in Table 3.2 below.

Table 3.2: Description and measurement of variables

	Variable	Variable description	Measurements	Expected sign
Y	Dependent variable	Adoption of exotic fodder shrubs	1 = if adopted and 0 otherwise	+ve
X_1	AGEHH	Age of the household head,	Years	+ve,-ve
X_2	SEHH	Gender of household head	It takes 1 if male, O otherwise	+ ve
X_3	F. SIZE	Total Family size	Number of persons in a household	+ ve
X_4	EDUC.	Education level of household head or farmer	1 =secondary and above and 0 = primary and below	+ ve
X_5	FAS	membership to a farmers' association or group	1 = belongs to a group 0 =otherwise	+ ve
X_6	EXT.CONT	Contact with extension agents	1 = has access to extension service and 0 otherwise	+ve
X_7	L.SIZE	Family land size	Acres	- ve
X_8	L.OWNER	Farm ownership	1 = individual ownership 0 = communal	+ ve
X_9	P. Other	Presence of other income enterprises in the farm	Takes the value of 1 if present and 0 otherwise	- ve
X_{10}	I. Dairy	Importance of dairy(milk) as a source of income	1 =if it is important 0= if it is not important	+ ve
X_{11}	(D.QUA)	Dairy cows' quality	1 = grade and 0= zebu	+ ve
X_{12}	T. Rent	If fodder/crop field was rented	It take 1 if it is and 0, otherwise	- ve
X_{13}	I. Other	Importance of income from competing enterprise	1=if it is important or very important and 0= if it is not.	- ve
X_{14}	A. SEEDS	Access to seeds or seedlings	1 = accessible and 0= otherwise.	+ve
X_{15}	MKT PROB.	Market access problems	1 =if milk market problems exist and 0 otherwise	-ve
X_{16}	MILSOL	Amount of milk sold per day	Litres	+ ve

Gender of household head (Gender HH) was used as a proxy indicator for gender and referred to the gender of the farmer. It took the value of 1 if the farmer was a male and 0 otherwise. Given the less favorable terms for women, it was expected that households headed by females would adopt less.

Family size (F. Size) was the total size of the farm household. It was a proxy to labour availability and may a priori influence the adoption of Calliandra and Leuceana shrubs technology positively as its availability reduces the labour constraints faced in fodder shrubs production and utilization. It was, therefore, expected that the larger the family size, the greater was the availability of labor for fodder tree farming, hence, more adoption.

Education (EDU**)** augments one's ability to receive, decode and understand information relevant to making innovative decisions. Thus it was hypothesized that dairy producers with more education were more likely to be adopters than farmers with less education. It was assigned the values 0 for no formal education or at least primary and 1 for secondary and above.

Social capital variables considered were group membership and contact with extension providers. Membership to farmers association (FAS) was another variable used in the model. This measured if the farmer is a member of a farmers' association or extension groups. It was assigned the value of 1 if the farmer belonged to a farmer organization or group and 0 for otherwise. It was hypothesized that there was a higher likelihood for those farmers who were members to farmers groups to adopt fodder shrubs.

Contact with technology promoters (EXT.CONT) was a dummy variable that was to measure the contact of farmers with research or extension agencies that worked or promoted fodder trees in the Sub-County. It was assigned the value of 1 if the household had access to extension service and 0 otherwise It was hypothesized that extension contact was positively related to adoption decision.

Natural capital included variables such as land size and ownership. Land size (L. SIZE) was to measure the family land size in acres. It was expected that the smaller the family land size, the higher the likelihood of adoption of fodder trees. Land or farm ownership (L.OWNER) measures whether ownership influence adoption decision. It is hypothesized that individual ownership favours adoption decisions. It was assigned the value of 1 if individual ownership and 0 if communal.

Bio-physical capitals were factors such as importance of dairy, land leasing for fodder, competing enterprises and seed availability. Importance of dairy in the households (I. Dairy) was a variable that measured the farmers' perception on importance of dairy enterprise as a source of income for the household where the farmers are located. It was expected that households where milk is perceived to be very important income source may have greater likelihood of adopting exotic fodder tree farming.

It takes the value of 1 if the livestock enterprise (milk) was perceived to be important or very important source of family income and 0 otherwise. Dairy cows' quality (D.QUA) measured the quality of the dairy cows kept by the farmers. It was hypothesized that farmers were highly likely to be motivated to plant fodder trees if they have good quality or improved dairy cows. It was assigned the value of 1 if livestock was grade or high quality crosses and 0 if livestock was zebu or poor quality crosses.

Rented fodder plots (T. Rent) was used as a dummy variable that indexes whether the crop field is a rented plot or not. It was assigned the value of 1 if it was and 0 otherwise.

It was expected that rented fodder plots were negatively related to adoption as renting a fodder or crop field may be an indication of land scarcity or limited access to land.

Competing enterprise (I-Other) variable measured the importance of competing income generating enterprise such as tea. Hence, importance of income from competing enterprise was hypothesized to be negatively related. Importance of income from competing enterprise such as tea was therefore; assigned a value of 1 if it was important or very important and 0 if it was not important.

Seed Availability (S.ACCE) or Accessibility variable measured seed availability to various would be adopters. It was assigned the value of 1 if readily available or available and 0 if it was scarce or very scarce. Seed accessibility was hypothesized to influence adoption decisions in that lack of seed or seedlings or their inability to access by the smallholder dairy farmers may have inhibited adoption decisions.

Under market access factors, the study considered milk marketing problems. Market access factors (MKT PROB) refer to the existence or non-existence of local markets offering good sales opportunities for dairy products. Hence it was hypothesized that farmers' problems on milk market as a proxy for market access factor negatively affect the decision to adopt and the decision on how much to adopt exotic fodder shrubs.

It was also hypothesized that the amount of milk sold or unsold to the market was considered as a proxy measure of the expected benefits an economic agent obtained, and that benefit suggest the probability of adoption is positively related to the amount of milk sold to the market and vice versa. Market access was also captured by the variable of farmer's perception of the milk market. It was assigned the value of 1 if the household face milk market problems and 0 otherwise.

3.9 Hypothesis Testing and Inference

3.9.1 To Determine if the Mean Values of Adopters and Non-Adopters' Socio-Economic Characteristics are Different:

To achieve objective one and hypothesis one, the null hypothesis H$_0$: $\mu_{i1} = \mu_{i2}$ was tested against the alternative H$_a$: $\mu_{i1} \neq \mu_{i2}$ at 5% level of significance with the aim of rejecting the null hypothesis if $|z| \geq z_{\frac{\alpha}{2}}$.

The test statistics was given by:

$$|z| = \frac{\mu_1 - \mu_2}{\sqrt{\frac{\sigma_1^2}{\eta_1} + \frac{\sigma_2^2}{\eta_2}}} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots ...$$

(3.12)

Where, μ_1 is the population mean values of the explanatory variables of adopters, μ_2 is the population meanvalues of the explanatory variables of non-adopting dairy farmers of Calliandra and Leuceana shrubs, σ_1 is the standard deviation of population 1, σ_2 is the standard deviation of population 2 and η_1 and η_2 are the sample size of population 1 and 2 respectively. $|z|$ is the test statistic, $z_{\frac{\alpha}{2}}$ is the critical value and α is the level of significance.

3.9.2 Testing the Significance of the Model

To achieve the second objective and hypothesis two, the Log likelihood ratio test was used (Greene, 1993) for testing the joint hypothesis about all or a subset of coefficients, in the Logit model. The log likelihood ratio test follows a chi-square distribution with j degrees of freedom (where j is the number of parameters in the equation other than constant).

The likelihood ratio statistic (LR) usedwas given by:

$LR=-2(In\ L_r-In\ L)$……………………………………………………………… (3.13)

Where $L_r$and L are the log likelihood functions evaluated at the restricted and unrestricted estimates. This test is similar to the F-test that all of the slopes in the regression are zero. For this test, the constant term remains unrestricted. In this case, the restricted log likelihood for the Logit model was given by;

$In\ L_0 =n\ [P\ In\ P + (1-P)\ In\ (1-P)]$ ………………………………………………… (3.14)

Where P is the proportion of the observations that have dependent variable equal to 1 and n is the sample size. The test was used to test the null hypothesis H_0: $\beta_1 = \beta_2 \ldots \beta_k = 0$ against the alternative hypothesis H_1: *at least one* of the β_k is nonzero. Where i =1, 2, -------, k.The aim was to reject H_0 if the computed chi-square statistic value was greater than or equal to the critical value from the chi-square Table.

3.9.3 Testing the Significance of Individual Coefficients

This was done using the t-test to confirm from the data whether the (K-1) explanatory variables in the choice model individually have any bearing on dependent variable Y_i (Hill*et al.*, 2003). To find out whether the data contained any evidence suggesting Y_i is related to X_i, the third null hypothesis (H_0: B_k= 0), was tested against the alternative hypothesis H_1: $B_k \neq 0$ with the aim of rejecting the null hypothesis if $t \geq 1.984$ and $-t \leq -1.984$ or $|t| \geq 1.984$.

To carry out this t-test, the testequation below, which, if the null hypothesis is true, is,

$$t = \frac{b_k}{se(b_k)} \quad t_{(T-K)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(3.15)

For the sample of T=116 data observations, the degrees of freedom were T-K=116-11=105. Therefore, With 105 degrees of freedom and 5% significance, the critical values that lead to a probability of 0.025 in each tail of the distribution were t_c =1.984 and $-t_c$ = -1.984.

For the alternative hypothesis " not equal to" the two tailed test was used with the aim of rejecting H_0 if the computed t-test value was greater than or equal to t_c(the critical value from the right side of the distribution), or less than or equal to $-t_c$(the critical value from the left side of the distribution).

3.9.4 Measuring Goodness of Fit

According to Greene (1993), there have been many attempts to derive fit measures for the qualitative response (QR) models like the Logit. Since the main hypothesis was that all the slopes in the model were zero, the log likelihood computed with only a constant term, In L_0(as $In\ L_0 = n\ [P\ In\ P + (1-P)\ In\ (1-P)]$ should also be reported.

An analog to the R^2in a conventional regression model is the likelihood ratio index (LRI),

$LRI=1-In\ L/In\ L_0$……………………………………………………………… (3.16)

The measure has an intuitive appeal in that it is bounded by zero and 1. If all of the slopes coefficients are zero, it is equal to zero. There is no way to make LRI equal to 1, although one can come close. It has been suggested that LRI increases as the fit of the model improves. Unfortunately, Greene (1993) infers that such values that fall between zero and 1 have no natural interpretation.

3.10 Estimation of the Probability and Prediction of Adoption

The values of the logits (estimates) have little interpretation value unless they are transformed into probabilities. Hence given a certain level of explanatory variable, to estimate not the odds in favor of adoption but the probability (P) of adoption of Calliandra and Leuceana as livestock feed supplements was done directly from equation (3.7) once the parameter estimates ($B_{i's}$)were available to facilitate computation of Z_i.

Therefore, to estimate the probability of Calliandra and Leuceana shrubs adoption for an individual farmer:

$$P_i = \frac{\exp^{Z_i}}{1+\exp^{Z_i}} = \frac{e^{Z_i}}{1+e^{Z_i}}$$

……………………………………………………… ...(3.17)

Where,

$$Z_i \quad \frac{P_i}{1-P_i} \;] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.18)$$

¿ ∈ ¿

$$¿\,\alpha + \sum_{j=1}^{n} B_j X_{ji}$$

= $\alpha +$ ¿ $B_1 X_1 + B_2X_2 + B_3X_3$ ………..+ $B_nX_n + \mu$…………………………………………

(3.19)

Hence;

$Z_i = \alpha + B_1 X_1 + B_2X_2 + B_3X_3$ ……………………….+ B_jX_i…………………...................(3.20).

3.11Assessment of Policy Intervention

To achieve the third objective, the effects of policy changes on adoption level of Calliandra and Leuceana shrubs were derived from the logistic regression results and the computed estimates of the probabilities and prediction of adoption following Sharma, (1997). The logistic regression results provided the significant determinants of adoption which were the focus of policy interventions in this study whereas the results of computed estimates of the probabilities and prediction of adoption indicated the overall mean probability of adoption ($\sum \frac{P_i}{T}$) and predicted the number of adopters ($\sum P_i$) with the existing resources (without any policy intervention).

Policy interventions were directed towards the significant determinants of adoption of Calliandra and Leuceana fodder species by first increasing the number of dairy farmers having the significant characteristic to cover all the farmers in the sample while holding other factors constant (for example, in the case of access to extension services, all the zeroes representing dairy farmers who lack contact with extension services are substituted with ones). After a single policy intervention, a comparison of the predicted number of adopters before and after the policy change provided a measure of its impact. The impact of several policies combined on adoption was achieved by simultaneously increasing the number of farmers with important characteristics to cover all the farmers in the sample.

3.12 Limitation of the Study

Most of the small holder dairy farmers interviewed did not maintain farm records hence the author depended on the farmer’s ability to remember.

CHAPTER 4

RESULTS AND DISCUSSIONS

This study investigated the influence of the various socio-economic factors on the adoption and use of Calliandra and Leuceana species as dairy feed supplements. This was in light of the low adoption level of these fodder species among the smallholder dairy farmers in Kisii Central Sub-County of Kenya. The data collected was analysed using descriptive statistics, frequencyTables and logistic regression.

This chapter presents the results, interpretation and discussion as follows: Section 4.1 present the socio-economic characteristics of sampled households while section 4.2.1 deals with study findings on adoption constraints faced by small holder dairy farmers in Kisii Central Sub-County. The empirical determinants of adoption of Calliandra and Leuceana fodder shrubs are discussed in section 4.2.2. Finally, impact of policy interventions on Calliandra and Leuceana species adoption are presented and discussed in section 4.3.

4.1 Socio-Economic Characteristics of Sampled Households: A Descriptive Analysis

The first objective of this study was to describe the socio-economic characteristics of adopters and non-adopters of Calliandra and Leuceana species in Kisii Central Sub-County of Kenya. To achieve this objective, descriptive statistics were generated from the survey data and the results are summarized in the Table in Table 4.1.

Table 4.1: Characteristics of the Adopting and Non-Adopting Dairy Farmers in the Analysis of Fo Adoption as Dairy FeedsSupplement					
X	**variable**	**MEAN VALUES**			**PERC**
		Adopters	Non-Adopters	All farms	Adopters
Sample Size(n)		36	80	116	31%
X_1	**Age** years)	43.43	45.22	43.98	45.22
X_2	**Gender** a)Male	32	37	69	89%
	b)Female	4	43	47	11%
X_3	**Family Size**	8	7.15	7.41	8
X_4	**Education** a)Secondary and above	21	29	50	58%
	b)Primary and below	15	51	66	42%
X_5	**Membership to groups** a)Members	34	14	48	94%
	b) non members	2	66	68	6%
X_6	**Extension Contact** a)With Contact	34	25	59	94%
	b)Without Contact	2	55	57	6%
X_7	**Land Size**	3.4	2.57	2.75	3.4
X_8	**Land Ownership** a)Individual	36	68	104	100%
	b)communal	0	12	12	0.00
X_9	**Presence of other income** a)Present	28	67	95	78%
	b) not present	8	13	21	22%
X_{10}	**Importance of dairy**(milk**)** a)Important	30	44	74	83%
	b)not important	6	36	42	17%
X_{11}	**Dairy cow quality** a)Grade Cows	34	44	78	94%
	b)Zebus or poor grades	2	36	38	6%
X_{12}	**Land Rent** a)Fodder plot rented	5	39	44	14%
	b)fodder plot not rented	31	41	72	86%
X_{13}	**Importance competing enterprise** a)Important	8	44	52	22%
	b)Not important	28	36	64	78%
X_{14}	**Access to seeds or seedlings** a)Accessible	32	0	32	89%
	b)Not accessible	4	80	84	11%
X_{15}	**Market access problems** a)problem Existed	3	26	29	8%
	b)No milk marketing problem	33	54	87	92%
X_{16}	**Amount of milk sold per day**	6.82	3.75	4.70	6.82

Source: Field Survey, August 2008

4.1.1 Age of Household Head

The descriptive statistic results in Table 4.1 shows that the age of heads of household ranged from 30 years to a maximum of 56 years, with an overall mean of 44 years. The mean age of the adopters was 43 years whereas that of non-adopters was 45 years. These results indicate adopter's age was relatively lower than that of the non-adopters suggestingolder people adopted less.

The results of analysis in Table 4.2 shows that the test statistic ($|z| ¿ was\ 0.85$ for age and the critical value ($z_{\frac{\alpha}{2}}$) at 5% significant level according to the normal distribution Table is 1.96. These results indicate that there is no significant age difference between those who had adopted and those who had not adopted Calliandra and Leuceana species for use as dairy feed supplements at 5% significant level ($|z| = 0.85 < z_{\frac{\alpha}{2}} = 1.96 ; \alpha$ <0.05). Therefore, Ho: $\mu_1 = \mu_2$ isaccepted.

4.1.2 Gender of Household Head

Among the sampled households, 59.5% were male whereas female were 40.5%.The resultsindicate that 89% of all adopters weremenwhereas women adopters accounted for only 11% (Table 4.1).The femaleheaded non adopters were 54% of all surveyed farmers with maleheaded non adopters being 46%.According to these results, there were more female headed households among non-adopters than male headed ones. This may be related to the fact that men have more access to resources and hence are able to adopt Calliandra and Leuceana species as dairy feed supplements.

4.1.3 Household Size

With a total population of 365,745 people and 81,426 households, Kisii Central Sub-County had an average family size of 5 persons (Gok, 2009). However, within the sampled households, family size differed greatly between the sampled households. The results shows family size ranged from 3 persons to a maximum of 22 family members with an average family size of 7 persons (Table 4.1).The mean family size of the adopters was 8 persons whereas that of non-adopters was 7.1 persons. These results suggest that adopters had slightly higher family size than non-adopters. This could be due to the fact that family labor provides a greater bulk of the farm labor requirement hence larger family size was an incentive to adopt fodder shrub technology.

4.1.4 Education Level

The results in Table 4.1 also shows that 43% of the sampled household heads had secondary education and above with the remaining 57% percent constituting those with primary education and below. Among the adopters, 58% had secondary education and above with those with primary education and below accounting for 42%. Among the non-adopters, 65% had primary education and below while those with secondary education and above being 35%.These results indicate that majority of adopters had secondary education and above while most non-adopters were those with primary education and below.

This could be attributed to the fact that Calliandra and Leuceanafodder trees farming and management to some extent are knowledge and management intensive technology. Higher education level is therefore necessary in Calliandra and Leuceana adoption since it equip the farmer with ability to manage the hedgerows properly to achieve optimal results. Henceeducation acts as an incentive to adopt the technology.

4.1.5 Membership to Farmers Association or Group

The descriptive statistic results further shows that 41% of dairy farmers were members of extension groups while non-members accounted for 59%.Among the adopters, the percentage of small holder dairy farmers who were members of agricultural extension groups in the sample was 94% whereas only 6% of adopters were non-members. The percentages of members and non-members to extension groups among the non-adopters were 18% and 82% respectively (Table 4.1).These result sindicate clearly that most adopters were members while most non adopters were not. Wambugu *et al.*, (2006) explained that dairy farmers working in focused groups rather than individual have many advantages. Interaction and information flow among the group members enhances the dissemination and adoption process. It is therefore necessary to promote Calliandra and Leuceana fodder species through extension groups.

4.1.6 Contact with Extension Agents

The results shows that 51% of the sampled household had contact with extension workers with 49% indicating they had no contact with extension agents promoting Calliandra and Leuceana fodder shrubs. Further, 94% of adopters had contact with extension providers with 6% adopting without contact with extension providers. Of those who had not adopted,31% had extension contact whereas 69% had not (Table 4.1).These results thus suggest that adopters had more extension contact than non-adopters.

The results of the analysis in Table 4.2indicate that there is a significant difference between the means of adopters and non-adopters as far as contact with extension agents is concerned ($|z| = 9.75 > z_{\frac{\alpha}{2}} = 1.96; \alpha$ <0.05). These findings confirm the findings suggested above in Table 4.1. The null hypothesis (Ho: $\mu_1 = \mu_2$¿ is rejected.Extension contact is therefore a significant incentive to adoption. This could be explained by the fact that contact with extension providers allowed farmers to get information on the technology and possibly see or participate in a demonstration. This means that availability or non-availability of technical officers with information on Calliandra and Leuceana technology to the dairy farmers will greatly determine whether one will be an adopter or not.

4.1.7 Family Land Size and Ownership

There was great variation on land size among the sampled respondents with the lowest farm size being 0.1ha and the highest being 4.6 ha. On the whole, the mean land size was 0.44hawith the adopters having a mean of 0.544haand the non-adopters having 0.411ha (Table 4.1).These results show that larger farm sizes within the surveyed area favored fodder shrubs adoption.

This could mean the extremely small land sizes among most surveyed dairy farmers were a disincentive to the adoption of the fodder shrubs. Where a farmer was experiencing acute land constraint, there was less incentive to adopt Calliandra and Leuceana.

The descriptive statistic results on land ownership also indicate that on the overall, 90% of the farmers had individual ownership with only 10% interviewed having communal ownership (Table 4.1). These results therefore suggest that the land tenure in Kisii Central Sub-County is mainly free hold which gives the farmer an opportunity to decide on the land use.

Among the adopters, the percentage of individual ownership was 100% meaning all the adopters individually owned the land where Calliandra and Leuceana species were planted. Among the non-adopters, 85% of them had individual ownership with 15% communal. This means that individual and ownership was an incentive to the adoption of these fodder shrubs. Where the land was not subdivided, adoption of the fodder shrubs was non-existent.

The results of test of significance showed that $|z|=3.75>z_{\frac{\alpha}{2}}=1.96;\alpha$ <0.05 ¿ ¿ Table 4.2).The null hypothesis (Ho: μ_1 = μ_2¿. This analysis indicates that the data supported the suggestion that individual land ownership was significantly higher among the adopters than non-adopters at 5% level. These results mean that promotion efforts of Calliandra and Leuceana species ought to be directed mainly to those farmers who individually owned their land.

The percentage of dairy farmers from the sample who had rented land to plant fodder was 38% with 62% growing fodder on their own farms. This shows that a good number of smallholder dairy farmers relied on land leasing to grow fodder for their dairy animals. This could be a disincentive to dairy production since money used to lease land ended up reducing the returns from dairy enterprise.

Among the Calliandra and Leuceana adopting farmers, 86% had not rented fodder plots with 14% having rented. The percentage of non-adopters with rented fodder plots were 49% with 51% having not rented (Table 4.1). Statistical test results ($|z|=4.29>z_{\frac{\alpha}{2}}=1.96;\alpha$ <0.05)shows that land renting, which indicated land scarcity, was highly significantly lower among the adopters than among the non-adopters of Calliandra and Leuceana fodder species (Table 4.2).The null hypothesis (Ho: $\mu_1 = \mu_2$¿ was rejected. These results suggest that non-adopters were mainly those smallholder dairy farmers who were experiencing land pressure or scarcity.

This suggests that land renting is a significant constraint to adoption of these fodder shrubs for use as livestock feed supplements in the larger Kisii Central Sub-County. These findings corroborate Clay*et al*., (2002) and Lynne*et al.,* (1988), who had also found in their study that renters displayed less adoption effort of agro-forestry technologies than owners did. The study therefore revealed that farmers who operated rented land were less likely to adopt the technology. This could be due to the short leasing agreement.

4.1.8 Presence of Other Income Earning Enterprises in the Farm

On the overall, 82% of the smallholder dairy farmers' household sampled had other income generating enterprises on their farm. The percentages of the adopters who had other income generating enterprises on their farms were 78% with 22% of the adopters having only dairy enterprise. For the non-adopters, 84% had other income generating enterprises other than dairy (Table 4.1). These results indicate that a large proportion of both the adopters and non-adopters had multiple income generating activities on their farm. This means that farmers could find ways to accommodate fodder shrub technologies into their farming systems depending on dairy incentives, profitability and competitiveness.

As to whether income from other enterprises were more important than dairy income, 45% of the sampled households perceived other enterprises in the farm to be more important than dairy with 55% perceiving them to be less important. A total of 78% of the adopters felt that income from competing enterprises was less important with 22% perceiving them as more important than dairy income.

However, among the non-adopters, 55% perceived competing enterprises to be more important than dairy and 45% said competing enterprises were less important. These results suggest that most adopters of Calliandra and Leuceana species perceived other competing enterprises to be less important than dairy enterprise. However, majority of non-adopters perceived other competing enterprises to be better than dairy.

The test results ($|z| = 3.64 > z_{\frac{\alpha}{2}} = 1.96 ; \alpha$ <0.05) revealed that evidence exists from the data to suggest that adopters' perception of importance of other income generating enterprise was significantly different from that of non-adopters at 5% significant level (Table 4.2). The null hypothesis (Ho: $\mu_1 = \mu_2$¿ was rejected. This means that the farmer's perception on other competing enterprises on the farm was quite critical while making adoption decisions of these fodder species since most adopters perceived dairy to be more important than other enterprises within the farm.

4.1.9 Importance of Dairy (Milk) as a Source of Income

The overall percentage of farmers who perceived dairy income to be very important was 64% with 36% considering it not important. The adopters who considered dairy income as very important was 83% with 17% of adopter considering dairy income as not important. The non-adopters who considered dairy income as important were 55% with

45% considering it not important (Table 4.1). These results suggested that most of the agro forestry technology adopters considered dairy income to be very important.

The results of the analysis in Table 4.2 indicated that the difference between the perceptions on importance of milk as an income generating enterprise between the adopters and non-adopters was significant at 5% level ($|z|=3.36>z_{\frac{\alpha}{2}}=1.96;\alpha$ <0.05).The null hypothesis (Ho: $\mu_1 = \mu_2$¿ was rejected.

The study therefore established that the perception on importance of milk as a source of income was different for adopting and non-adopting farmers. The null hypothesis is therefore rejected. These findings supported a suggestion that adopter's perceived income from the dairy enterprise to be very important whereas non-adopters did not. It is therefore necessary for the technology promoters to analyze the farmers' perception on milk as a source of income as a prerequisite to technology beneficiary selection.

4.1.10 Dairy Cows' Quality

The percentage of farmers from the sample who had grade or good quality dairy cross-breeds was67% with 33% of surveyed farmers having zebu or low yielding dairy breeds. The percentage adopters with grade or high quality dairy crossbreeds were94% with only 6% of the adopters having zebus or poor quality cross-breeds. On the other hand, 55% and 45% of the non-adopters had grade dairy cows and zebus respectively (Table 4.1).The results show that the majority of adopting farmers had grade and high quality dairy cross-breeds whereas most non-adopters were those with low quality cross-breeds or zebus.

The analysis results in Table 4.2revealed that there was significant difference in terms of dairy breed owned by the adopters and those owned by non-adopters at 5% significant level ($|z|=5.82>z_{\frac{\propto}{2}}=1.96;\propto$ <0.05).The null hypothesis (Ho: μ_1 = $\mu_2¿$ was rejected.These findings could mean that the dairy cow quality is a major determinant of total milk yield and eventual level of dairy income. This high milk yield or income acted as an incentive to dairy farmers to adopt fodder shrubs for use as dairy feed supplement.

4.1.11 Other Characteristics

Among the surveyed dairy farmers, 28% had access to Calliandra and Leuceana fodder species seeds or seedlings with 72% being unable to access the same. This could explain the non-adoption of this technology by the majority of dairy farmers in Kisii Central Sub-County. About89% of adopters had access to the exotic fodder shrub seeds or seedlings with 11% of adopters expressing the desire to increase the adoption if they could access more seed or seedlings (Table 4.1).

This shows that there was acute scarcity of this vital input among sampled households. All the non-adopters surveyed did not access Calliandra and Leuceana seeds or seedlings. The results suggest that adopters were those dairy farmers who accessed the seeds whereas non-adopters were those who did not.

The difference between the adopters and non-adopters in terms of accessibility to seeds was statistically significant at 5% level as shown: $|z|=16.80>z_{\frac{\propto}{2}}=1.96;\propto$ <0.05 (Table 4.2). This agreed with Wambugu *et al*, (2006) who had suggested that availability of good quality seed is often the greatest constraint to scaling up the adoption of fodder shrubs in most parts of Kenya.

From the sampled households in Kisii Central Sub-County, 25% had milk marketing problems with 75% saying they did not experience marketing problems. The percentage of Calliandra and Leuceanaadopters with milk marketing problems was 8% with 92% of adopters indicating non-existence of milk marketing problems. Thenon-adopters with milk marketing problems were 33%.

The results in Table 4.2indicatethat adopters experienced less milk marketing problems than non-adopters at 5% level ($|z|=3.42>z_{\frac{\propto}{2}}=1.96;\propto$ <0.05).This shows that milk marketing problems, where they existed, acted as dis-incentive to these fodders shrub adoption. The study reinforced Wambugu *et al*, (2006) findings that farmers who are unable to sell their milk may have no interest in new practices for increasing milk production. The mean amount of milk sold per day per household was 4.7 litres.

The mean for the adopters was 6.82 litres whereas that for the non-adopterswas3.75 litres per day. Results of analysis indicates that the mean milk sold by adopters was significantly different from that of non-adopters at 5% level ($|z|=2.14>z_{\frac{\propto}{2}}=1.96;\propto$ <0.05).This shows that the agro forestry species adopters were selling more milk per day than the non-adopters. The adopters' dairy enterprise was therefore doing better than that of non-adopters.

able 4.2: Summary Tests of Significance of Various Means of Adopters and Non-adopters Socio-Economic Characteristics

Socio-economic Characteristics	μ_1	μ2	μ1-μ2	σ1	σ2	σ_1^2	σ_2^2	η2	η1	$\frac{\sigma_1^2}{\eta_1}$	$\frac{\sigma_2^2}{\eta_2}$	$\frac{\sigma_1^2}{\eta_1}+\frac{\sigma_2^2}{\eta_2}$	$\sqrt{\frac{\sigma_1^2}{\eta_1}+\frac{\sigma_2^2}{\eta_2}}$	$\lvert z \rvert = \frac{\mu_1-\mu_2}{\sqrt{\frac{\sigma_1^2}{\eta_1}+\frac{\sigma_2^2}{\eta_2}}}$	5% significance
Age	45.2	43.4	1.80	10.14	11.2	102.9	125.4	36	80	2.859	1.57	4.426		0.85	
Gender	0.89	0.46	0.43	0.32	0.50	0.10	0.25	36	80	0.003	0.003	0.006	0.316	1.35	
Family size	8.00	7.15	0.85	2.27	2.86	5.14	8.21	36	80	0.143	0.103	0.245	0.500	1.70	
Education	0.58	0.36	0.22	0.50	0.48	0.25	0.23	36	80	0.007	0.003	0.010	0.316	0.70	
Group membership	0.56	0.18	0.38	0.50	0.38	0.25	0.15	36	80	0.007	0.002	0.009	0.316	1.20	
Extension contact	0.94	0.31	0.63	0.23	0.47	0.05	0.22	36	80	0.001	0.003	0.004	0.065	9.75	*
Land size	3.14	2.57	0.57	2.07	1.99	4.28	3.97	36	80	0.119	0.050	0.169	0.412	1.38	
Land ownership	1.00	0.85	0.15	0.00	0.36	0.00	0.13	36	80	0.000	0.002	0.002	0.040	3.75	*
Presence other	0.78	0.84	-0.06	0.42	0.37	0.18	0.14	36	80	0.005	0.002	0.007	0.082	-0.73	
Importance milk	0.83	0.55	0.28	0.38	0.50	0.14	0.25	36	80	0.004	0.003	0.007	0.084	3.36	*
Dairy quality	0.94	0.55	0.39	0.23	0.50	0.05	0.25	36	80	0.001	0.003	0.005	0.068	5.82	*
Land rent	0.14	0.49	-0.35	0.35	0.50	0.12	0.25	36	80	0.003	0.003	0.007	0.081	-4.29	*
Importance other	0.22	0.55	-0.33	0.42	0.50	0.18	0.25	36	80	0.005	0.003	0.008	0.090	-3.64	*
Seeds availability	0.89	0.00	0.89	0.32	0.00	0.10	0.00	36	80	0.003	0.000	0.003	0.053	16.80	*
Market problem	0.08	0.33	-0.24	0.28	0.47	0.08	0.22	36	80	0.002	0.003	0.005	0.071	-3.42	*
Milk sold	6.82	3.75	3.069	8.25	3.54	68.12	12.54	36	80	1.892	0.157	2.049	1.432	2.14	*

Source: Field Survey, August 2008. (* indicate significance at 5%)

4.2 Constraints and Socio-Economic Determinants of Calliandra and Leuceana Adoption as Dairy Feed Supplement

The second objective of this study was to understand adoption constraints and determine socio-economic factors that influence the adoption of Calliandra and Leuceana species.

4.2.1 Constraints to Adoption of Calliandra and Leuceana Species by Small Holder Dairy Farmers in Kisii Central Sub-County

The results as shown in Table 4.3 indicates that limited information or farmer's awareness was the major reason given by the farmers for non-adoption of agro-forestry technology (43.6%). This could be explained by the reduced farmer: staff ratio which stood at 1:5000 (Gok-MOLD, 2008). This huge coverage area per extension staff could have contributed to this lack of awareness on importance of Calliandra and Leuceana as feed supplements among the smallholder dairy farmers in Kisii Central Sub-County. This agro-forestry technology is knowledge intensive, requiring more knowledge and skills than many other practices (Wambugu *et al.*, 2006).

Lack of technical knowledge on how to plant, nursery establishment and management and transplanting the seedlings were also found to be a major constraint and a major limiting factor to adoption by Gladwin *et al.,* (2002). These results also concur with CAB, (2002) that technical trainings make tremendous difference in farmer's ability to manage new technologies on both an individual and their communities than farmers who had not benefited from comparable training.

Table 4.3Constraints to Adoption of Calliandra and Leuceana Fodder Species

Reason/Constraints	No. of Respondents	Percentage
Limited land size(small piece of land)	19	16.4
Limited information(awareness)	51	43.6
Lack of seed or seedlings	42	36
Insufficient training	3	3
Lack of interest	1	1
Total	**116**	**100**

Source: Field Survey, August 2008

The constraint of limited information was followed by lack of seed or seedlings (36%).This constraint could be due to absence of entrepreneurs engaged in fodder shrub seed marketing or commercialized seed distribution system in Kisii Central Sub-County. The farm input shops, where farmers could easily access the seeds did not stock fodders shrub seeds.

This finding concurs with Wambugu *et al*., (2006) findings that concluded that availability of good quality seed is often the greatest constraint to scaling up the adoption of fodder shrubs. Limited land size (16.4%) though structural in nature was the third major constraint to adoption. Other adoption constraints given by the dairy farmers were, insufficient training (3%) and lack of interest (1%).

Using stepwise regression analysis, the Maximum likelihood estimates of the coefficients (βi) were computed for the 10 explanatory variables while 7 were dropped due to either perfect prediction or collinearity. The Table 4.4 below presents the logistic regression results of estimated coefficients of the parameters.

Table 4.4 Logistic Regression Results

Estimates B 95% confidence level

Variable	**Coef.**	**Std. Err.**	**z**	**P>z**	**[95% Conf.**

							Interval]
Age	β_1	-0.071	0.043	-1.650	0.099	-0.156	0.014
Gender	β_2	3.355	0.956***	3.510	0.000	1.482	5.228
Family size	β_3	0.293	0.138**	2.120	0.034	0.022	0.564
Education	β_4	0.355	0.766	0.460	0.643	-1.147	1.857
Group membership	β_5	1.161	0.811	1.430	0.152	-0.428	2.750
Extension contact	β_6	4.085	1.072***	3.810	0.000	1.985	6.186
Land size	β_7	0.268	0.249	1.070	0.283	-0.221	0.7560
Presence of other enterprises	β_8	-0.431	1.071	-0.400	0.687	-2.530	1.668
Dairy breed	β_9	3.675	1.095***	3.360	0.001	1.529	5.821
Milk sold	β_{10}	0.009	0.090	0.100	0.924	-0.167	0.184
Constant	β_0	-9.160	2.634	-3.480	0.001	-14.321	-3.998

N=116

Log likelihood =27.8449

Prediction=100%

Likelihood ratio(Ch2 with 10 degree of freedom)=88.01**

Pseudo R2=0.612

Prob>ch2=0.0000

The *, ** and *** referred to statistically significant at 10%, 5% and 1% respectfully.

Source: Field Survey, August 2008

The results of logistic regression in Table 4.4above shows that the farmers' decision on adoption of Calliandra and Leuceana shrubs for use as dairy feed supplement was positively determined by gender of the household head, family size, extension contact, dairy breed, education, membership to extension groups, land size, and amount of milk sold. The effect of age of the household head and presence of other income generating enterprises within the farm were negative.

It therefore means that all things being equal, households headed by males adopted more than female headed households. Male headed households in the Sub-County were more likely to be adopters of this technology than female headed households. These results on gender agree with Place *et al*., (2002) that improved natural resource technologies more generally fail to be adopted by women farmers at the same rate as male farmers. This could be due to male farmers enjoying more and greater wealth, education and socio-economic powers than women farmers.

The positive effect of family size indicated that larger families adopted more than smaller families as anticipated. This could be attributed to the fact that family size determined the quantity of labor available for use in fodder shrubs establishment and utilization and therefore, large family acted as an incentive to adopt this labor intensive technology. Family labour availability also reduced the labour constraints faced in fodder shrubs production and utilization. This suggestion concurs with the descriptive results obtained earlier in section 4.1.7. These results, however, contradicted findings by Wyatt, (2002) who had found large family size decrease the probability of adopting soil management technologies in Madagascar and Niger.

Contact with extension providers had positive influence on the adoption of Calliandra and Leuceana fodder species. This means that those dairy farmers with more access to extension services actually adopted more. This also pointed out by the descriptive results in section 4.1.6.This positive relationship was also supported by Teklewold *et al*., (2006); CAB, (2002)and Adesina and Forson, (1995).CAB, (2002) had also found that small holder farmers will take up even complex agricultural technologies if given sufficient technical support. Access to more extension services enhanced the efficiency of making adoption decisions of this technology and hence, its positive influence. Smallholder dairy farmers in the Sub-County with better access to extension services were more likely to be adopters of this technology than farmers with limited contact with extension providers.

The positive influence of dairy breed quality on adoption meant that high quality dairy breed was an incentive to Calliandra and Leuceana adoption in the Sub-County. This supported Wambugu *et al*., (2006), that farmers are highly likely to be motivated to plant fodder trees if they have good quality dairy breeds or improved dairy cross-breeds. Dairy households with high quality dairy breed adopted more than those with zebu breeds. This showed that poor quality dairy breeds were a constraint to adoption of this technology and therefore, dairy breed improvement strategies could be a vital consideration of increasing adoption rate of this technology in the Sub-County.

Positive relationship of education level of household head on adoption indicated a higher likelihood of adoption by those with secondary education and above than those with primary level and below. More education level acted as an incentive to adoption decision. This finding agreed with Wozniak (1984) and Teklewold *et al.*, (2006) that education augments one's ability to receive, decode and understand information relevant to making innovative decisions.

This means that farmers with more education are more efficient in evaluating and interpreting information about innovations than those with less education. However, the results disagreed with Wyatt, (2002) who found education of the household head to be a negative factor in the adoption decision since according to the researcher, higher education opens up alternative avenues and may even be a means of leaving agriculture entirely.

Membership to extension groups had positive relationship with adoption probability. This indicates that there were higher success rates of adoption when working with farmer groups as pointed by Attah-Krah and Francis (1987, Versteeg and Koudokpon (1993) and Mose*et al.,* (2000). Working with groups to enhance Calliandra and Leuceana adoption could therefore be more effective than working with individual farmers since a culture of collective action which exists in groups will make it easier for group members to adopt more.

Land size influence on adoption of Calliandra and Leuceana was expected to be negative in line with Wambugu *et al*., (2006) who had suggested that fodder shrubs farming should be targeted to areas with high population density and small land sizes. However, the results show that land size in Kisii Central Sub-Countywas positively related to adoption, which means that dairy farmers with larger land parcels were better placed to be adopters of Calliandra and Leuceana shrubs than those with small land parcels.

Farmers with very small land acreages were less likely to adopt Calliandra and Leuceana shrubs. This finding confirmed that the extremely small land holdings in this densely populated Sub-County acted as a constraint and a disincentive to adoption of these exotic fodders. This finding was reinforced by the responses given in Table 4.3 where 16% of respondents gave small land parcels as a reason for non-adoption and in descriptive statistic results of section 4.1.7.

The effect of age of the household head on adoption of Calliandra and Leuceana fodder shrubs was supposed to be answered empirically. The results showed age was negatively related to adoption which meant the younger the household head, the higher was the likelihood that he would adopt Calliandra and Leuceana fodder shrubs. This negative relationship supported Adesina and Forson (1995), suggestions that older farmers may be more risk averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting Calliandra and Leuceana fodder shrubs. Younger dairy farmers could also be relatively more educated which makes them more efficient in interpreting technical information regarding Calliandra and Leuceana shrubs than older farmers.

Presence of other income generating enterprises within the farm was negative as anticipated in the study. This meant that households with many income generating enterprises within the farm were less likely to adopt than those who had only dairy. This could be due to income generating enterprises competing for the same scarce resources especially land and labour.

This competition in the process madeCalliandra and Leuceana shrubs less an attractive option. This led to reduced demand for this technology among those who had other income generating enterprises such as tea or horticulture within their farms. This outcome brought into doubt the competitiveness of the dairy enterprise for scarce resources such as land and labour within the household farm in the Sub-County.

It also meant that the incentives in dairy enterprise were not sufficiently high to make small holder dairy farmers in this Sub-County accommodate this technology in their farming system. According to Place *et al.* (2002), farmers commonly find ways to accommodate new technologies into their farming systems when incentives are sufficiently high.

4.2.2 Hypothesis Testing and Inference

To determine if all of the slopes in the logistic regression were zero (in line with second objective and hypothesis $H_0 2$), the log Likelihood ratio statistics (LR) which follows a chi-square distribution was used as explained in equation (3.13) and (3.14) under methodology. The results of this computation are shown in Table 4.4.

The logistic regression results of Table 4.4shows that the LR or chi-square statistic is 88.01 and with 10 degrees of freedom, the critical value (χ_C^2¿ from the chi-square Table at 95% confidence level is 18.31.This result indicates that the adoption of Calliandra and Leuceana fodder species was significantly determined jointly by the farmer's socio-economic characteristics at 95% confidence level (χ^2=88.01> χ_C^2 =18.31; $\propto =$¿ 0.05; df=10,106). The study established that farmers' socio-economic characteristics jointly influence the adoption of Calliandra and Leuceana as dairy feed supplements in Kisii Central Sub-Countyof Kenya.

Therefore the joint null hypothesis that the coefficients on age, gender, family size, education, group membership, extension contact, land size, presence of other enterprises within the farm, milk sold and dairy breed were all zero (H_0: $\beta_1 = \beta_2 = \ldots \beta_k = 0$)was rejected. This means that for any progress to be made in the adoption of the fodder species, efforts should be made to address these socio-economic factors. These findings uphold Adesina and Forson, (1995), Sharma, (1997) suggestions that the observed choice to adopt an agricultural technology is the end result of socio-economic characteristics of farmers.

To determine if the individual variables in the model had significant influence on the adoption of Calliandra and Leuceana fodder species, the t-test (equation 3.15) was used. The results of this analysis are summarized in Table 4.4 and discussed below. The results indicate that age of the household head have no significant influence on the adoption of Calliandra and Leuceana fodder species in Kisii at 5% significance level($t=1.65<1.984$; $\propto <0.05$; df=11,105).The null hypothesis (H_0: $\beta_1 = 0$) is therefore accepted.

The results of Table 4.4 also indicate that adoption of Calliandra and Leuceana fodder species is significantly influenced by the gender of the household head at 95% confidence level ($t=3.51> t_c =1.984$; $\propto <0.05$; df=11,105). This finding concurs with the findings suggested by Table 4.2. The study therefore establishes that gender of household head influences the adoption of Calliandra and Leuceana fodder species in Kisii Central Sub-County. The null hypothesis (H_0: $\beta_2 = 0$) was rejected. This means that the probability of adoption was higher for households headed by male than those headed by female.
These results reveal existence of gender discrimination as far as female headed households was concerned and that adoption of fodder shrubs technology among the small holder dairy farmers in Kisii Central Sub-County was pre-dominantly a man’s activity. These findings agreed with those obtained in a study on determinants of adoption of poultry technology in Ethiopia (Teklewold *e. al.*, 2006) and Adesina and Chianu, (2002) in their study on alley farming technology in Nigeria.

The results of Table4.4 indicates that family size has a significant influence on Calliandra and Leuceana adoption ($t=2.1>t_c=1.984$; $\propto <0.05$; df=11,105). These findings establish that family size, which was a proxy variable for labour, influence adoption of Calliandra and Leuceana fodder species as dairy feed supplements in Kisii Central Sub-County. The null hypothesis (H_0: $\beta_3 = 0$ was rejected. This means strategies that will ensure availability of farm labour influence the adoption of this technology among the small holder dairy farmers in Kisii Central Sub-County.

The influence of education of household head on Calliandra and Leuceana adoption was not significant ($t = 0.5 < t_c = 1.984$; $\propto$ <0.05; df=11,105) as shown in Table 4.4. The null hypothesis (H_0: $\beta_4 = 0$) was therefore accepted. The data did not support the conjecture that education of the household head significantly influenced adoption of Calliandra and Leuceana fodder shrubs at 95% confidence level.

To determine whether membership to extension group significantly influence adoption of Calliandra and Leuceana shrubs,H_0: $\beta_5 = 0$ was tested againstH_1: $\beta_5 \neq 0$.The results indicates that membership to extension group does not significantly influence adoption of Calliandra and Leuceana fodder species as dairy feed supplements in Kisii Central Sub-County ($t=1.43<t_c = 1.984$; $\propto$ <0.05; df=11,105). This result led to the acceptance of the null hypothesis.

According to Table 4.4, contact with extension agent has a significant influence on Calliandra and Leuceana species adoption ($t=3.8 < t_c = 1.984$; $\propto$ <0.05; df=11,105). The null hypothesis (H_0: $\beta_6 = 0$) was rejected. This result led to the argument that extension contact significantly influences adoption of Calliandra and Leuceana species in Kisii Central Sub-County. This means that there was evidence from the data to suggest adoption of exotic fodder species significantly depended on contact of the farmer with extension providers at 95% confidence level. These findings suggest that dairy farmers with contact with agricultural researchers and extension agencies have greater likelihood of adopting Calliandra and Leuceana fodder species in the Sub-County. This result is corroborated by findings by Adesina and Chianu, (2002) and Adesina *et al*, (1997).

The result for land size indicates that land size has no significant influence on Calliandra and Leuceana adoption ($t=1.1<t_c = 1.984$; $\propto$ <0.05; df=11,105). The null hypothesis (H_0: $\beta_7 = 0$) was accepted and a suggestion was made that adoption of Calliandra and Leuceana fodder species in Kisii Central Sub-County does not depend on land size of the farmer at 95% confidence level.

The hypothesisH_0: $\beta_8 = 0$was tested against H_a: $\beta_8 \neq 0$ to determine whether the influence of the presence of other income generating enterprises within the farm on adoption was significant at 5%level.The results shows that presence of other income generating enterprises within the farm does not significantly influence Calliandra and Leuceana adoption in Kisii Central Sub-County ($t=-0.403 <t_c = 1.984$; $\propto$ <0.05; df=11,105).

The results for the amount of milk sold indicate that the variable has no significant influence on adoption of Calliandra and Leuceana species ($0.10<t_c = 1.984$; $\propto$ <0.05; df=11,105). The null hypothesis (H_0: $\beta_9 = 0$) was therefore accepted. This result means that there was no evidence from the data to suggest amount of milk sold from the farm influenced adoption of Calliandra and Leuceana fodder shrubs in Kisii Sub-County at 95% confidence level.

On whether the influence of dairy cow quality on adoption of Calliandra and Leuceana was significant or not,H_0: $\beta_{10} = 0$ was tested against H_a: $\beta_{10} \neq 0$.The results obtained indicate that dairy cow breed or quality significantly influences adoption of exotic fodder species in the Sub-County ($t=-3.36>t_c = 1.984$; $\propto$ <0.05; df=11,105).Therefore, the null hypothesis(H_0: $\beta_{10} = 0$) was rejected. This result suggests that dairy cow quality is an important determinant of Calliandra and Leuceana fodder species adoption in Kisii Central Sub-County. This means that improving the breed quality of the existing dairy cows in Kisii Central Sub-County could be a prerequisite to the adoption of Calliandra and Leuceana fodder species.

4.2.3 Measuring Goodness of Fit

This was carried out using equation (3.16) as described in section 3.7. The Likelihood Ratio Index (*LRI)* was computed as shown below:

$$LRI=1-In\ L/In\ L_0=1-(-27.844912/-71.8481)=1-(0.38755)=0.6124.$$

Since as suggested the LRI increases as the fit of the model improves, the value above informed the proportion of variation in the dependent variable explained by the explanatory variables and the predictive ability of the model over the sample.In this case, the computed LRI indicated that the model had good explanatory ability and fitted the data well.

4.2.4 Computation of Probabilities of Adoption

Using equation (3.7) under methodology and estimated coefficients as shown in Table4.4 the predicted probabilities of Calliandra and Leuceana adoption for the selected farmers were computed as follow:

$$Z_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta X_3 \text{-----------------------} + \beta_j X_i$$

$$= -9.16 - 0.071 (X_1) + 3.355 (X_2) + 0.293 (X_3) + 0.355 (X_4) + 1.161 (X_5) + 4.085 (X_6) + 0.268 (X_7) - 0.431 (X_8) + 0.009 (X_9) + 3.675 (X_{10}).$$

For a 48 years old (X_1) male(X_2) with a family size of 10 (X_3), has a secondary education and above(X_4), a member of an extension group(X_5), with extension contact(X_6),land size of 5acres(X_7),with other farm enterprises(X_8),selling 15 litres of milk per day(X_9),and owning a high quality breed of dairy cow(X_{10}) was computed as:

Z_i =-9.16-0.071 (48) +3.355 (1) + 0.293 (10) +0.355 (1) +1.161 (1) +4.085 (1) +0.268 (5) -0.431 (1) +0.009 (15) +3.675 (1) = 4.0117.

The probability of such a farmer adopting exotic fodder shrubs given e=2.7182819 were hence computed as below:

$$P_i = \frac{\exp^{Z_i}}{1+\exp^{Z_i}} = \frac{e^{Z_i}}{1+e^{Z_i}} = \frac{e^{4.0117}}{1+e^{4.0117}} = \frac{2.7182819^{4.0117}}{1+2.7182819^{4.0117}} = \frac{55.24225}{56.24225} = 0.98222 \text{ or } 98\%$$

A farmer with the above resources was likely (P>98 percent) to adopt Calliandra or Leuceana fodder shrubs as dairy feed supplements. The probabilities for all individual farmers were computed similarly as shown in the Table in the appendix 5. The following was therefore deduced from appendix 5:

The sum ($\sum P_i$) predicted the number of adopters and was given by;

$\sum P_i$ =35.99944=36.

This showed that all the cases were correctly predicted by the model as shown in TableA5.The overall mean probability of adoption was given by;

$$\sum \frac{P_i}{116} = 35.99944/116 = 0.31034 = 31\%$$

The mean probability of an adopter was given by;

$$\frac{\sum P_i(adopters)}{36} = \frac{27.37129}{36} = ¿ \quad = 0.760314 = 76\%$$

The mean probability of a non-adopter was given by;

$$\frac{\sum P_{i(nonadopters)}}{80} = \frac{8.62871}{80} = 0.107859 = 10.8\%$$

4.3 Impact of Policy Interventions on Calliandra and Leuceana Shrubs Adoption

The third objective of this study was to investigate effects and impacts of various policy interventions on the adoption level of Calliandra and Leuceana in Kisii Central Sub-County. To achieve this objective, logistic regression results in Table4.4 was used in which policy interventions were directed towards the important (significant) determinants of adoption of Calliandra and Leuceana shrubs namely; gender, membership to extension groups, extension contact and dairy cow quality. These were selected not only due to their significant influence to adoption but also, their amenability to policy interventions. The results of computation of probabilities in section 4.2.5 indicate that with the existing resources and without any policy interventions, only 36 dairy farmers (31%) would adopt Calliandra and Leuceana species as dairy feed supplements. However, if the number of dairy farmers having access to extension service was increased to cover all the farmers in the sample, other factors remaining constant, the number of adopting farmers increased to 51.78 (44.6%). The same was done to gender, dairy cow breed and membership to extension groups. Finally, the number of the farmers with the significant determinant to adoptions was increased simultaneously to assess the impact of combining several policy interventions. The results are summarized in Table 4.5 below:

Table 4.5: Effects of Policy Alternatives on Adoption of Calliandra and LeuceanaShrubs

Policy	Predicted number of adopters	%change in adoption rate after policy intervention	%adoption rate among farmers after policy intervention.
1. No change(present situation)	36	0	31%
2. Affirmative action targeting	46	8.66%	39.66%

	women farmers			
3.	Increased access to extension groups	41.7	4.9%	35.9%
4.	Increased extension contacts or services	51.78	13.6%	44.6%
5.	Dairy breed improvement	44.34	7.2%	38.2%
6.	Affirmative action targeting women farmers+ Increased access to extension	71.82	30.9%	61.9%
7.	Increased access to extension services + Dairy breed improvement	67.78	27.4%	58.4%
8.	Increased access to extension services+ Dairy breed improvement + Affirmative action targeting women farmers	95.66	51.46%	82.46%
9.	Increased access to extension services+ Dairy breed improvement+ Increased access to extension groups+ Affirmative action targeting women farmers	106.39	60.7%	91.7%

Source: Author's data 2008

The results in Table 4.5 indicate an adoption rate of 31% with the existing resources. However, with various policy changes, higher adoption rate of this technology could be achieved. If a policy on an affirmative action that target all female small holder dairy farmers to ensure they have an equal opportunity as men was formulated, all things being equal, the level of adopters will increase to 46 which is 39.66 percent. This is an increase of 8.66% over the original situation.

A policy intervention leading to increased membership to extension groups had the smallest impact of increasing the adopters to 42, which was only 4.9% compared to increasing the extension contacts to the smallholder dairy farmers which had the greatest impact of 13.6% over the initial situation.

As noted earlier, policy intervention leading to increased extension contact raised the adoption rate to 44.6%.Improving the dairy quality increased the adoption rate to 38.2%, an increase of 7.2%.Combining several policies resulted in greater predicted impact than when the policies were done individually. When the policies on affirmative action and increased access to extension were combined, the number of adopters increased to 72, with an adoption rate increasing to 61.9%.

This resulted in a combined impact of 30.9%.On the other hand, combining three policies of increased access to extension services, dairy breed improvement and affirmative action had an impact of 51.46% and increased the predicted adoption rate to 82.46% with 96 dairy farmers adopting the technology.

The greatest impact was achieved by combining the four policies of increasing access to extension services; dairy breed improvement; increased access to extension groups and affirmative action targeting women farmers. The number of adopters increased to 106,anincrease of 75 farmers translating to an increase of 60.7% and a total adoption rate of 91.7%.

From the results in Table 4.5, it can be suggested that increasing access to extension services, improving the quality of dairy cow, ensuring that more dairy farmers join extension groups and designing an affirmative action for women dairy farmers are likely to increase the adoption of Calliandra and Leuceana shrubs as dairy feed supplement.

CHAPTER 5

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This section presents the summary, conclusions, and recommendations of the undertaken study and suggestions for further research.

5.1 Summary of Findings

The first objective of this study was to describe the socio-economic characteristics of adopters and non-adopters of Calliandra and Leuceana species in Kisii Central Sub-County of Kenya. The following is a summary of the findings from this objective: First, data analysis and interpretation of descriptive statistics revealed that the adopter's age (43 years) was relatively lower than that of the non-adopters (45 years) and that the main adopters of Calliandra and Leuceana shrubs were male headed households (89%).

On average, Calliandra and Leuceana fodder species adopters have larger family size (8) thannon-adopters (7) and most of the adopters had secondary education and above (58%) with most non adopters having primary education and below (65%). Majority of the adopters were members of agricultural extension groups in the surveyed areas (94%) whereas most non adopters were not (83%).

There were more adopters who had contact with extension providers (94%) than those who had not adopted (31%). The mean land size of the adopters (0.544 ha) was slightly higher than that of the non-adopters (0.411 ha). As a whole, the land tenure in Kisii Central Sub-County is mainly free hold which gives the farmer an opportunity to decide on the land use.

The percentage of the adopters who had other income generating enterprises in the farm (78%) was lower than that of non-adopters (84%). Majority of Calliandra and Leuceana fodder species adopters (83%) also considered dairy income as very important enterprise whereas 45% of non-adopters considered dairy income as not very important. The adopting farmers also had grade and high quality dairy crossbreeds (94%) whereas non-adopters were those with poor crossbreeds or zebus (45%).

The total number of smallholder dairy farmers who relied on land leasing to grow fodder for their dairy animals were 44 (38%) of which five (14%) were adopters and 39 (49%) were non adopters. Majority of adopters of Calliandra and Leuceana fodder species (78%) felt that income from competing enterprises was less important. However, 55 percent of the non-adopters, perceived competing enterprises to be more important than dairy. The data collected showed that there was scarcity of Calliandra and Leuceana seeds among sampled households with 72% not being accessible to seeds. The non-adopters who had milk marketing problems were 33% whereas 92% of the adopters did not have. Finally, adopters were producing more milk per day(6.8 liter) than non-adopters (3.8 litres per day).

The second objective of this study was to understand adoption constraints and determine socio-economic factors that influence the adoption of Calliandra and Leuceana species as dairy feed supplements among the smallholder dairy farmers in Kisii Central Sub-County and the following is the summary of the findings: first, the respondents gave various reasons for non-adoption and limited information or farmer’s awareness was the major reason given by the farmers for non-adoption of this technology (43.6%). This was followed by lack of seed or seedlings (36%), Limited land size (16.4%), insufficient training (3%) and lack of interest (1%).

Secondly, the logistic regression results showed that the farmers' decision on adoption of exotic fodder shrubs for use as dairy feed supplement was significantly and positively influenced by gender of the household head, family size, extension contact and dairy quality. The effect of age of the household head and presence of other income generating enterprises within the farm were negative but not significant. Other coefficients such as education, membership to extension groups, land size, and amount of milk sold had positive effects but were not significant either.

The joint hypothesis that the coefficients on all the explanatory variables are all zero was rejected at 95% confidence level. On measuring goodness of fit, the predictive ability of the model over the sample was 0.61245 (61.2%).The mean probability of an adopter was; $\sum P_i$ (adopters) 76% whereas the mean probability of a non-adopter was; $\sum P_i$ (non-adopters) 10.8%.

The third objective of this study was to investigate effects and impacts of various policy interventions on the adoption level of Calliandra and Leuceana in Kisii Central Sub-County. Under this objective, various impacts of policy interventions on exotic fodder shrubs adoption were computed to facilitate making policy oriented recommendations. Without any policy changes and with the existing resources, only 31% of small holder dairy farmers would adopt Calliandra and Leuceana shrubs as dairy feed supplements in Kisii Central Sub-County. However, with various policy interventions, better impacts could be achieved.

If a policy on an affirmative action to target all female small holder dairy farmers was formulated, all things being equal, the level of adopters increased by of 8.66% over the original situation. A policy change leading to increased extension services to all the farmers had the greatest impact of 13.6% over the initial situation. However, combining several policies resulted to greater predicted impact of 106 farmers (91.7%) adopting than when the policies were done individually.

5.2 Conclusion

This study investigated the socio-economic factors influencing adoption of Calliandra and Leuceana shrubs as feed supplements among the small holder dairy farmers in Kisii Central Sub-County of Kenya. It was intended to increase understanding by researchers, extension service providers and other organizations on the influence of various socio-economic factors on Calliandra and Leuceana adoption for use as dairy feed supplements. This was in relation to the low adoption of Calliandra and Leuceana fodder species for use as dairy feed supplements among the small holder dairy farmers in Kisii Central Sub-County.

The study specifically sought to describe the socio-economic characteristics of adopters and non-adopters of Calliandra and Leuceana fodder shrubs in Kisii Central Sub-County; understand adoption constraints and determine socio-economic factors that significantly influence the adoption of fodder shrubs as feed supplements ; investigate effects and impacts of various policy interventions on the adoption level of Calliandra and Leuceana in Kisii Central Sub-County and to make policy recommendations to private and public sector technology promoters on ways of enhancing adoption of Calliandra and

Leuceanafodder shrubs as dairy feed supplements. The study established the following major findings:

First, the main and significant differences between the Calliandra and Leuceana fodder species adopters and non-adopters were in extension contacts, landownership, land renting and perception of importance of other enterprises within the farm. Perception on the importance of dairy enterprise profitability, dairy cow quality, accessibility to seeds and existence of milk marketing problems within the farms were also significantly different between the adopters and non-adopters.

The Calliandra and Leuceana fodder species adopters could therefore be described as those smallholder dairy farmers who had more extension contact, individually owned their land and were not experiencing land shortage. They also perceived income from dairy enterprise to be more important than other enterprises within the farm, had high yielding dairy breeds, were accessible to seeds and were not experiencing milk marketing problems.

In view of these findings, it can be suggested tha tlack or inaccessibility to extension services, failure to demarcate family land, land scarcity, existence of more profitable income generating enterprises within the farm, seed shortage and existence of milk marketing problem, among others are the major reasons for non-adoption of Calliandra and Leuceana fodder species technology in Kisii Central Sub-County.

Secondly, from the logistic regression and tests of the hypothesis that “adoption and use of Calliandra and Leuceana shrubs as feed supplement is not influenced by farmers social economic characteristics”, the study established the following findings:

The farmers' decision on adoption of Calliandra and Leuceana shrubs for use as dairy feed supplements was found to be significantly and positively influenced bygender of the household head, family size, extension contact, and dairy quality. The other variables were not significant. These include, age of the household head, presence of other income generating enterprises within the farm , education, membership to extension groups, land size, and amount of milk sold.

These second findings from the study suggest that availability of farm labor and quality dairy cows were positive incentives to the adoption of exotic fodder shrubs whereas labor constraint and poor dairy breeds contributed significantly to non-adoption of this technology. Gender biases, inadequate extension contact, and high labor requirement by the technology and poor breeds of dairy cattle are therefore some of the most significant constraints to adoption of exotic fodder shrubs particularly for female headed households.

Since gender was highly significant and positively related to the adoption of this technology, a suggestion can be made that this technology is not gender neutral. Some gender biasness which placed female household heads at a disadvantaged position when it comes to making adoption decisions of this technology existed in the Sub-County.

Since gender of the household head, extension contact, and dairy quality factors plays a very significant role in determining Calliandra and Leuceana technology adoption, they needed to be considered by the various promoters and policy makers of this technology in Kisii Central Sub-County since they are also amenable to policy interventions

The findings also suggest that efforts to enhance adoption of this technology should focus on policy amenable variables. An affirmative action that targets female headed households, increased access to extension services and dairy breed improvement strategies are vital policy interventions to be considered seriously when policy-makers deliberate on ways to increase adoption rate of this technology among the small holder dairy farmers in the Sub-County. Several policies interventions needed to be combined since this will result to higher adoption level than when the policies were done individually.

5.3 Recommendations

Basing generalizations on the findings of this study, several recommendations were made.

First, policy makers within the Ministry of Livestock development should explore strategies of extension services intensification to ensure the technology reach every dairy farmer. This can be achieved through consistent staff recruitment to reduce the staff: farmer ratio.

Second, since the adoption of Calliandra and Leuceana technology is an important ingredient to the intensification and increase in productivity and output of smallholder dairy enterprise, Ministry of Livestock development and other stakeholders support in smallholder dairying should be extended to female headed dairy farmers. This means that programmes involved in the promotion of this technology among the smallholder dairy farmers need to take into consideration the special needs of female headed households through special targeting policy.

Third, the study also recommended that to address the constraint of poor dairy breed, the Ministry of Livestock Development formulate dairy breed improvement policy which will make artificial insemination services (A.I) not only accessible to majority of small holder dairy farmers but also affordable. This can be achieved through government sponsored subsidy on A.I cost.

Fourth, the marketing system for milk was generally informal and poorly developed in most parts of the Sub-County. This implies that facilitating access to marketing of dairy products is an obvious prerequisite for dairy development which will predispose the dairy farmer to adopt the Calliandra and Leuceana fodder species technology. Hence, farmers' cooperatives for the marketing of dairy products should be encouraged and promoted.

Fifth, the small holder dairy farmers should also be given production based incentives such as input subsidies. These incentives should be directed to improving the competitiveness of the dairy enterprise for land and other resources within the Sub-County. This will make it profitable for farmers to accommodate Calliandra and Leuceana fodder species technology on their farms. To stem Calliandra and Leuceana seeds scarcity incentives should also be given to input stockists to encourage these entrepreneurs to stock and distribute seeds to the small holder dairy farmers in the Sub-County.

Finally, the study also recommends that several policy alternatives should be combined in order to achieve optimal adoption behavior. This will results to the achievement of widespread adoption and long-term benefits of adopting Calliandra and Leuceana fodder species technology for sustainable smallholder dairy production in Kisii Central Sub-County.

5.4 Areas for further research

Further research is suggested to be done on the following areas;

The productivity of the already established fodder shrubs was observed to be low. Research should therefore be carried out to determine the reasons why this is so and suggest ways in which this productivity can be improved.

Since the uptake of this technology was significantly low among female dairy farmers, research should also be carried out to find out Constraint hindering female farmers adoption of agricultural technologies at the same rate as menKisii Central Sub-County of Kenya

Finally, investigations also need to be carried out on the role of marketing of dairy products in the adoption of livestock based technologies in Kisii Central Sub-Countyof Kenya.

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APPENDICES

Appendix 1: Research questionnaire

Dear respondent,

My name is Stephen Gachege and am a postgraduate student in the Department of Economics and Agricultural Resource Management, Moi University. I am carrying out a research for partial fulfillment of the requirements for the award of the degree of Masters of philosophy in Agricultural Economics and Resource Management of Moi University. This questionnaire is purely for academic purpose. It is aimed at gathering information to determine socio-economic factors influencing adoption of Calliandra and Leuceana shrubs as feed supplements among the small holder dairy farmers in Kisii Central Sub-County. All information gathered will be treated with high confidentiality. Your co-operation will be greatly appreciated.

Thank you.

Stephen Gachege,

Moi University.

Questionnaire number------------------

Name of interviewer: -----------------

SECTION A: GENERAL INFORMATION

a) Name of the household head (farmer):--

b) Date of interview: -------------------------.

c) Sub-County: ------------------------------------.

d) Ward :-----------------------------------

e) Location:-----------------------------------

f) Sub location: -----------------------------

g) Village: ----------------------------------.

h) Agro-eco Zone----------------------------

i) Population density: -----------------------

SECTION B: SOCIO-ECONOMIC CHARACTERISTICS

1) Household characteristics(farm operator characteristics):

   i) Age of Household head (farmer): --

   ii) Gender of the household head (farmer): □ Male □ Female

   iii) What is the Level of education of household head?

   □No education □At least primary level □Secondary and above

   iv) What are the main sources of farm labor? □ Family □ Hired labor

   v) If hired, what is the average number of hired laborers on daily bases? --------

   vi) Total Family size: --

   - Children below 10years:--
   - Above 10years but below 20years:---
   - Over 20years and unmarried:--

2) Dairy Cow characteristics:

   i) Type of dairy cows kept by the farmer ; □ zebu □ poor crosses

   □ good crosses □ grade cows

   ii) Number of zebu cows in the household--

   iii) Zebus in milk: ---

   iv) Current production level(litres / day / zebu cow):Cow 1--,Cow 2--- ,Cow 3--

v) Peak production level(litres / day / zebu cow); Cow 1--,Cow 2--- ,Cow 3------

vi) Number of grade cows: ---

vii) Grade cows in milk: --

viii) Current production levels(litres / day / grade cow): Cow 1-,Cow 2-,Cow 3-

ix) Peak production level(litres / day / grade cow) Cow 1--,Cow 2--- ,Cow 3-----

x) Average milk production per cow / day: --

xi) Total milk production per day (all cows):-----------------------------Per year------

SECTION C: CONTACT WITH TECHNOLOGY DEVELOPERS AND PROMOTERS:

1) Accessibility to extension services:

i) Have you been accessible to extension service? ☐Yes ☐ No

ii) If yes, from whom? ☐ Extension ☐KARI ☐CBOs ☐Others (specify)

iii) What is the frequency of the following extension activities in your farm?

☐No farm visits---

☐Training attended--

☐Tours--

2) Are you a member of a dairy farmers association or dairy Common interest group?

☐Yes ☐No

SECTION D: LAND AND FARM FODDER AVAILABILITY:

1) Land characteristics:

i) Total Land size (acres): --

ii) Is your land under communal or individual ownership?

☐Communal ☐Individual

iii) Do you have a title deed to your farm? ☐Yes ☐No

iv) Where have you planted most of your livestock fodder such as napier?

☐ On Rented plot ☐On communally owned land ☐On individually owned land

v) How much fodder (in acres) have you planted in:

☐ Rented or hired plot--------------

☐ communally owned land or plot-----------------

☐ individually owned land or plot. ---------------------------------------

vi) What is the size of the land (in acres) set aside for grazing? --------------acres.

vii) Do you consider your farm to be large enough to allow grazing? ☐Yes ☐No

viii) How available is grazing land in your household?

☐Grazing land easily available ☐Grazing land scarce ☐Grazing land very scarce

ix) How is the Farm fodder situation?

☐Fodder easily available ☐Fodder scarce ☐Fodder very scarce

2) How is the House hold fuel situation?

☐House hold Fuel easily available ☐Fuel wood scarce ☐Fuel wood very scarce

SECTION E: FODDER SHRUBS INFORMATION:

1) Technology awareness and information source:

i) Have you heard of exotic shrubs such as Calliandra and or Leuceana that are used as livestock or dairy feed? ☐Yes ☐No

ii) Source of information: ☐Researchers ☐Extension workers☐Other farmers

iii) Have you ever been trained on exotic fodder shrubs such as Calliandra and Leuceana shrubs for use as livestock feeds? ☐Yes ☐No

iv) If yes, how many days or times? --

v) On what aspects have you been trained? Tick where applicable.

☐Seed treatment ☐Nursery establishment

☐Transplanting ☐Spacing ☐Pruning

vi) What is the immediate use status? ☐Adopted ☐Not planted

vii) Are you aware of present organizations that promote these fodder shrubs?

☐Yes ☐No

viii) Have any of these shrubs (calliandra / Leuceana) growing in your farm?

☐Yes ☐No

ix) If yes, how many shrubs? --

x) If no, why? ---

xi) Do you know how to plant these trees? ☐Yes ☐No

xii) If yes tick what you can be able to do;

☐Seed treatment ☐Nursery establishment

☐Transplanting ☐Spacing ☐Pruning

xiii) Do you have knowledge on how to carry out the following activities?

- Harvest fodder shrubs : ☐Yes ☐No
- Feed fodder shrubs to dairy cows: ☐Yes ☐No
- Harvest seeds from these shrubs: ☐Yes ☐No

2) Seeds, seedlings availability and fodder shrubs adoption:

i) Do you have fodder shrub seeds or seedlings? ☐Yes ☐No

ii) Do you have knowledge of people with seeds or seedlings? ☐Yes ☐No

iii) How available are these seeds or seedlings?

□ Easily available □ available □ Scarce □ very scarce

iv) Have you ever seen for yourself the benefits of fodder shrubs? □ Yes □No

v) What is the ownership of the Field where Calliandra and Leuceana are planted?

□Personal land □Family or communal land □Hired land

vi) When did you first adopt exotic fodder shrubs in your farm for use as dairy fodder supplements? ----

vii) Number of years since adopted exotic Fodder shrubs? ---------------------------

viii) Are you still using Calliandra and Leuceana as dairy feed supplement?

□Yes □No (Abandoned)

ix) If no, give reasons why:--

x) If yes, what has been the shrubs population trend over time?

□ the shrubs population has been increasing over the years

□ the shrubs population has been decreasing over the years

xi) If the shrubs population has been decreasing or increasing over the years, indicate:□ The initial shrubs population? --

□ Current shrubs population? --

xii) What are main the reasons for either increase or decrease of the shrubs population over the years?---

SECTION F: MILK MARKETING AND COMPETING ENTERPRISES:

1) milk marketing:

i) How much milk do you produce per day in litres?---------------litres

ii) How much of the produced milk is actually sold per day?---------liters

iii) Do you have problem in marketing milk? ☐Yes ☐No

iv) If yes, amount of unsold milk per day is------------------------Litres.

v) If more milk is produced, will you be able to sell it easily? ☐Yes ☐No

vi) Distance to Kisii town (km): ---

2) Dairy competing enterprise:

i) How important is income from dairy enterprise (milk) in the household?

☐Not important ☐ Abit important ☐Important ☐Very important

ii) Do you have other income generating enterprises in your farm? ☐Yes ☐No

iii) If yes, list them and then rank them in order of priority

1. ---
2. ---
3. ---
4 . ---

iv) From the list above, is there a farm income generating enterprise which is more important than dairy? ☐Yes ☐No

v) If yes, which one? --

vi) How important is this competing cash enterprise i.e. tea? (tea)

☐ It is very important

☐ It is important

☐ It is not important

Appendix 2: Significance Level of the Various Socio-Economic Factors

variable	**t-value**	**20%(1.29)**	**10%(1.660)**	**5%(1.984)**	**1%(2.364)**
Age	-1.65	significance	Not significant	Not significant	Not significant
Gender	3.51	significance	significance	significance	significance
Family size	2.12	significance	significance	significance	Not significant
Education	0.46	Not significant	Not significant	Not significant	Not significant
Group membership	1.43	significance	Not significant	Not significant	Not significant
Extension	3.81	significance	significance	significance	significance
Land size	1.07	Not significant	Not significant	Not significant	Not significant
Presence of other enterprise	-0.40	Not significant	Not significant	Not significant	Not significant
Milk sold	0.10	Not significant	Not significant	Not significant	Not significant
Dairy quality	3.36	significance	significance	significance	significance

Source: Field Survey, August 2008.

Appendix 3: Computation of Probabilities of Adoption.

Dependent Variable (Y)	Estimates (B_i) Age	Gender	Family size	Education	Group membership	Extension contact	Land size	Presence other income	Milk sold	Dairy quality	Constant	Logits (Z_i)	exp^Z	1	$1+exp^{Z_i}$	Probabilities ($P_i=exp^{Z_i}/1+exp^{Z_i}$)
1	-3.426	3.3552	2.93044	0.35498	1.16101	4.0853	1.3376	-0.43115	0.1289	3.67504	-9.15991	4.01172	55.242246737	1	56.24225	0.98222
1	-3.426	3.3552	3.80957	0.35498	0	4.0853	0.6688	-0.43115	0.0172	0	-9.15991	-0.7257	0.483977215	1	1.483977	0.32614
1	-3.997	3.3552	2.6374	0	0	4.0853	0.6688	-0.43115	0.0344	3.67504	-9.15991	0.86839	2.383089011	1	3.383089	0.70441
1	-3.997	3.3552	2.6374	0.35498	1.16101	4.0853	0.8026	-0.43115	0.043	3.67504	-9.15991	2.52674	12.512650844	1	13.51265	0.92600
1	-3.426	3.3552	1.46522	0.35498	1.16101	4.0853	1.3376	-0.43115	0.043	3.67504	-9.15991	2.46057	11.711555453	1	12.71156	0.92133
1	-	3.3552	2.3443	0	1.16101	4.0853	0.936	-	0.025	3.6750	-	1.9952	7.354386589	1	8.35438	0.88030

	3.99 7		5				4	0.43115	8	4	9.15991	9			7	
1	- 3.42 6	3.3552	2.9304 4	0.35498	0	4.0853	3.076 6	- 0.43115	0.412 5	3.6750 4	- 9.15991	4.8732 2	130.74238364 9	1	131.742 4	0.99241
1	- 3.42 6	3.3552	2.6374	0	0	0	1.070 1	- 0.43115	0.008 6	3.6750 4	- 9.15991	-2.270	0.103263686	1	1.10326 4	0.09360
1	- 3.42 6	3.3552	2.0513 1	0	0	4.0853	0.668 8	- 0.43115	0.077 3	3.6750 4	- 9.15991	0.8962 3	2.450347497	1	3.45034 7	0.71017
1	- 3.99 7	3.3552	2.3443 5	0.35498	1.16101	4.0853	2.140 2	- 0.43115	0.085 9	3.6750 4	- 9.15991	3.6143 0	37.125534711	1	38.1255 3	0.97377
1	- 3.99 7	3.3552	1.7582 7	0.35498	0	4.0853	0.668 8	- 0.43115	0.051 6	3.6750 4	- 9.15991	0.3614 2	1.435378173	1	2.43537 8	0.58939
1	- 2.14 1	3.3552	1.7582 7	0.35498	0	4.0853	0.668 8	- 0.43115	0.085 9	3.6750 4	- 9.15991	2.2514 0	9.501076899	1	10.5010 8	0.90477
1	- 2.14 1	3.3552	2.0513 1	0.35498	1.16101	4.0853	0.535 1	- 0.43115	0.012 9	0	- 9.15991	-0.176	0.838294046	1	1.83829 4	0.45602
1	-	3.3552	1.1721	0.35498	0	4.0853	0.535	-	0.025	3.6750	-	1.4714	4.355331383	1	5.35533	0.81327

	2.141		8				1	0.43115	8	4	9.15991	0			1	
1	-3.997	3.3552	2.93044	0	1.16101	4.0853	1.0701	-0.43115	0.0086	3.67504	-9.15991	2.69796	14.849459986	1	15.84946	0.93691
1	-2.141	0	2.05131	0	1.16101	4.0853	0.5351	-0.43115	0.043	3.67504	-9.15991	-0.181	0.834080215	1	1.83408	0.45477
1	-2.141	0	2.34435	0.35498	1.16101	4.0853	0.2675	-0.43115	0.0602	3.67504	-9.15991	0.21625	1.241416666	1	2.241417	0.55385
1	-2.141	0	2.05131	0	0	4.0853	0.8026	-0.43115	0.043	3.67504	-9.15991	-1.075	0.341330180	1	1.34133	0.25447
1	-3.997	3.3552	3.51653	0	0	4.0853	0.2675	0	0.1031	3.67504	-9.15991	1.84613	6.335241281	1	7.335241	0.86367
1	-3.426	3.3552	2.34435	0	1.16101	4.0853	0.2675	0	0.1203	3.67504	-9.15991	2.42310	11.280781211	1	12.28078	0.91857
1	-3.426	0	2.34435	0.35498	1.16101	4.0853	0.1338	0	0.0172	3.67504	-9.15991	-0.814	0.443091116	1	1.443091	0.30704
1	-	3.3552	1.7582	0.35498	1.16101	4.0853	0.401	-	0.034	3.6750	-	1.8086	6.102366520	1	7.10236	0.85920

	3.426		7				3	0.43115	4	4	9.15991	8			7	
1	-3.997	3.3552	3.22349	0.35498	0	4.0853	1.0701	0	0.043	3.67504	-9.15991	2.6505	14.161050877	1	15.16105	0.93404
1	-3.426	3.3552	1.46522	0.35498	1.16101	4.0853	0.8026	0	0.0258	3.67504	-9.15991	2.33948	10.375823122	1	11.37582	0.91209
1	-2.141	3.3552	1.75827	0.35498	0	4.0853	0.4013	-0.43115	0.0344	3.67504	-9.15991	1.9323	6.905497614	1	7.905498	0.87351
1	-3.426	3.3552	1.75827	0	0	4.0853	0.6688	-0.43115	0.0344	3.67504	-9.15991	0.56022	1.751057953	1	2.751058	0.63650
1	-2.141	3.3552	1.46522	0	1.16101	4.0853	1.3376	0	0.1289	3.67504	-9.15991	3.9073	49.765650647	1	50.76565	0.98030
1	-3.426	3.3552	2.6374	0	0	4.0853	0.4013	0	0.0086	3.67504	-9.15991	1.5772	4.841336166	1	5.841336	0.82881
1	-3.997	3.3552	2.34435	0.35498	1.16101	4.0853	1.3376	0	0.0086	3.67504	-9.15991	3.1655	23.701231291	1	24.70123	0.95952
1	-	3.3552	3.2234	0.35498	1.16101	4.0853	1.070	-	0.103	3.6750	-	3.4405	31.202836371	1	32.2028	0.96895

	3.997		9				1	0.43115	1	4	9.15991				4	
1	-3.426	3.3552	2.93044	0.35498	1.16101	4.0853	0.4013	-0.43115	0.1031	3.67504	-9.15991	3.0496	21.106863037	1	22.10686	0.95477
1	-2.141	3.3552	2.05131	0.35498	0	0	0.8026	-0.43115	0.0172	3.67504	-9.15991	-1.476	0.228580439	1	1.22858	0.18605
1	-3.426	3.3552	1.75827	0.35498	1.16101	4.0853	0.8026	-0.43115	0.0086	3.67504	-9.15991	2.1841	8.883453597	1	9.883454	0.89882
1	-3.426	3.3552	3.51653	0	0	4.0853	0.9364	-0.43115	0.0086	3.67504	-9.15991	2.5602	12.938854355	1	13.93885	0.92826
1	-3.426	3.3552	2.93044	0	1.16101	4.0853	0.5351	-0.43115	0.043	3.67504	-9.15991	2.7682	15.930471154	1	16.93047	0.94093
1	-2.141	3.3552	1.46522	0	1.16101	4.0853	0.8026	-0.43115	0.0602	3.67504	-9.15991	2.8723	17.678987722	1	18.67899	0.94646
0	-2.141	0	1.75827	0	0	0	1.0701	-0.43115	0.0086	3.67504	-9.15991	-5.220	0.005406632	1	1.005407	0.00538
0	-	3.3552	2.3443	0	0	0	1.337	-	0.034	3.6750	-	-2.841	0.058357879	1	1.05835	0.05514

	3.99 7		5				6	0.43115	4	4	9.15991				8	
0	- 3.99 7	0	2.6374	0	0	0	0.802 6	- 0.43115	0.043	3.6750 4	- 9.15991	-6.429	0.001612843	1	1.00161 3	0.00161
0	- 3.99 7	0	1.7582 7	0	1.16101	0	0.535 1	0	0.034 4	3.6750 4	- 9.15991	-5.992	0.002496520	1	1.00249 7	0.00249
0	- 2.14 1	0	2.0513 1	0.35498	0	4.0853	0.535 1	- 0.43115	0.008 6	0	- 9.15991	-4.696	0.009123818	1	1.00912 4	0.00904
0	- 2.14 1	0	1.7582 7	0	0	4.0853	0.401 3	- 0.43115	0.025 8	0	- 9.15991	-5.461	0.004247323	1	1.00424 7	0.00423
0	- 3.42 6	3.3552	2.0513 1	0.35498	0	4.0853	1.070 1	- 0.43115	0.008 6	3.6750 4	- 9.15991	1.5837	4.873221903	1	5.87322 2	0.82974
0	- 2.14 1	3.3552	1.1721 8	0	0	0	1.337 6	- 0.43115	0.068 7	3.6750 4	- 9.15991	-2.123	0.119628891	1	1.119629	0.10685
0	- 3.99 7	0	3.8095 7	0.35498	0	0	1.337 6	0	0.077 3	3.6750 4	- 9.15991	-3.902	0.020200919	1	1.02020 1	0.01980
0	-	0	1.4652	0	0	4.0853	0.267	-	0.025	3.6750	-	-2.213	0.109346122	1	1.10934	0.09857

	2.14 1		2				5	0.43115	8	4	9.15991				6	
0	- 3.42 6	3.3552	1.7582 7	0.35498	0	0	1.070 1	0	0.017 2	0	- 9.15991	-6.029	0.002405677	1	1.00240 6	0.00240
0	- 2.14 1	0	1.4652 2	0.35498	0	0	0.535 1	0	0.008 6	0	- 9.15991	-8.937	0.000131416	1	1.00013 1	0.00013
0	- 3.99 7	3.3552	2.0513 1	0	0	4.0853	0.267 5	- 0.43115	0.008 6	3.6750 4	- 9.15991	-0.145	0.865227155	1	1.86522 7	0.46387
0	- 2.14 1	0	1.1721 8	0.35498	0	0	0.401 3	- 0.43115	0.034 4	3.6750 4	- 9.15991	-6.0942	0.002255728	1	1.00225 6	0.00225
0	- 2.14 1	0	1.4652 2	0.35498	0	0	0.401 3	- 0.43115	0.025 8	3.6750 4	- 9.15991	-5.809	0.002997935	1	1.00299 8	0.00299
0	- 2.14 1	0	2.3443 5	0.35498	0	0	0.267 5	- 0.43115	0.025 8	0	- 9.15991	-8.7395	0.000160134	1	1.00016	0.00016
0	- 3.99 7	0	1.7582 7	0	0	4.0853	1.872 7	- 0.43115	0.017 2	0	- 9.15991	-5.854	0.002867668	1	1.00286 8	0.00286
0	-	0	2.0513	0	0	4.0853	0.535	0	0.085	3.6750	-	-2.723	0.065616598	1	1.06561	0.06158

	3.99 7		1				1		9	4	9.15991				7	
0	- 3.99 7	0	6.4469 7	0	1.16101	4.0853	1.070 1	- 0.43115	0.008 6	0	- 9.15991	-0.815	0.442320698	1	1.44232 1	0.30667
0	- 3.42 6	3.3552	2.3443 5	0	0	0	0.200 6	- 0.43115	0.128 9	3.6750 4	- 9.15991	-3.313	0.036418493	1	1.03641 8	0.03514
0	- 3.42 6	0	2.6374	0	0	0	0.401 3	- 0.43115	0.017 2	0	- 9.15991	-9.961	0.000047210	1	1.00004 7	0.00005
0	- 3.99 7	3.3552	1.7582 7	0.35498	1.16101	4.0853	1.605 2	- 0.43115	0.068 7	0	- 9.15991	-1.199	0.301475960	1	1.30147 6	0.23164
0	- 3.42 6	0	2.0513 1	0.35498	0	0	0.802 6	- 0.43115	0.008 6	0	- 9.15991	-9.7993	0.000055489	1	1.00005 5	0.00006
0	- 3.99 7	0	2.9304 4	0	0	4.0853	1.203 9	- 0.43115	0.008 6	3.6750 4	- 9.15991	-1.684	0.185545313	1	1.18554 5	0.15651
0	- 3.42 6	0	2.9304 4	0	0	0	1.070 1	- 0.43115	0.008 6	3.6750 4	- 9.15991	-5.3326	0.004831486	1	1.00483 1	0.00481
0	-	0	1.4652	0.35498	0	0	0.535	-	0.017	0	-	-9.3597	0.000086126	1	1.00008	0.00009

	2.141		2				1	0.43115	2		9.15991				6	
0	-3.426	0	1.46522	0.35498	0	0	0.8026	0	0.0172	3.67504	-9.15991	-6.270	0.001891028	1	1.001891	0.00189
0	-3.426	3.3552	3.51653	0.35498	0	0	0.8026	-0.43115	0.0086	0	-9.15991	-4.978	0.006881447	1	1.006881	0.00683
0	-2.141	0	1.17218	0.35498	0	4.0853	0.1338	0	0.0344	3.67504	-9.15991	-1.845	0.157973300	1	1.157973	0.13642
0	-3.426	0	1.75827	0.35498	1.16101	4.0853	0.5351	-0.43115	0.1203	3.67504	-9.15991	-1.3268	0.265323883	1	1.265324	0.20969
0	-3.997	3.3552	1.75827	0	0	4.0853	1.0701	-0.43115	0.0086	3.67504	-9.15991	0.36477	1.440195258	1	2.440195	0.59020
0	-2.141	0	2.05131	0.35498	0	0	0.2675	0	0.0172	3.67504	-9.15991	-4.934	0.007190788	1	1.007191	0.00714
0	-3.997	3.3552	4.10262	0	0	0	0.6688	-0.43115	0.0687	3.67504	-9.15991	-1.717	0.179542191	1	1.179542	0.15221
0	-	0	1.1721	0.35498	0	0	0.267	-	0.128	3.6750	-	-6.133	0.002168927	1	1.00216	0.00216

	2.141		8				5	0.43115	9	4	9.15991				9	
0	-3.426	3.3552	2.05131	0.35498	0	0	0.5351	-0.43115	0.0258	3.67504	-9.15991	-3.019	0.048827974	1	1.048828	0.04655
0	-3.997	0	2.6374	0	1.16101	4.0853	1.0701	-0.43115	0.0258	3.67504	-9.15991	-0.933	0.393344091	1	1.393344	0.28230
0	-3.426	0	1.46522	0	0	0	0.8026	-0.43115	0.0172	0	-9.15991	-10.73	0.000021839	1	1.000022	0.00002
0	-3.426	3.3552	2.05131	0.35498	0	0	0.4013	-0.43115	0.0258	3.67504	-9.15991	-3.153	0.042714525	1	1.042715	0.04096
0	-3.997	3.3552	1.46522	0	0	0	0.8026	-0.43115	0.0086	0	-9.15991	-7.956	0.000350494	1	1.00035	0.00035
0	-3.997	3.3552	3.22349	0	0	0	0.4013	-0.43115	0.0172	0	-9.15991	-6.5906	0.001373212	1	1.001373	0.00137
0	-2.141	0	2.05131	0.35498	1.16101	4.0853	0.8026	-0.43115	0.0602	3.67504	-9.15991	0.4582	1.581330213	1	2.58133	0.61260
0	-	3.3552	2.3443	0	0	4.0853	0.401	0	0.008	0	-	-2.961	0.051723314	1	1.05172	0.04918

	3.997		5				3		6		9.15991				3	
0	-2.141	3.3552	2.34435	0.35498	0	4.0853	0.2675	-0.43115	0.0086	3.67504	-9.15991	2.3588	10.578912152	1	11.57891	0.91364
0	-2.141	3.3552	2.34435	0.35498	0	4.0853	0.0669	0	0.0086	3.67504	-9.15991	2.5893	13.321270920	1	14.32127	0.93017
0	-2.141	3.3552	1.75827	0	0	4.0853	0.2006	-0.43115	0.0172	0	-9.15991	-2.315	0.098713844	1	1.098714	0.08984
0	-3.997	3.3552	1.17218	0	0	0	2.9428	-0.43115	0.0516	3.67504	-9.15991	-2.391	0.091539995	1	1.09154	0.08386
0	-3.426	3.3552	2.05131	0.35498	0	0	0.2675	-0.43115	0.0258	0	-9.15991	-6.962	0.000947183	1	1.000947	0.00095
0	-3.997	3.3552	2.6374	0	0	0	2.1402	-0.43115	0.0258	0	-9.15991	-5.429	0.004386772	1	1.004387	0.00437
0	-2.141	3.3552	2.05131	0	0	0	2.6753	-0.43115	0.0258	0	-9.15991	-3.6245	0.026660071	1	1.02666	0.02597
0	-	3.3552	2.0513	0	0	0	0.401	-	0.008	0	-	-7.200	0.000746274	1	1.00074	0.00075

	3.426		1				3	0.43115	6		9.15991				6	
0	-3.426	0	3.22349	0	0	0	0.4013	-0.43115	0.0086	0	-9.15991	-9.3834	0.000084107	1	1.000084	0.00008
0	-2.141	0	1.46522	0	1.16101	0	0.9364	-0.43115	0.0086	0	-9.15991	-8.160	0.000285586	1	1.000286	0.00029
0	-3.997	3.3552	2.93044	0	0	0	0.5351	-0.43115	0.0344	3.67504	-9.15991	-3.057	0.046997607	1	1.046998	0.04489
0	-2.141	3.3552	0.87913	0	0	0	0.2675	0	0.0086	0	-9.15991	-6.7905	0.001124335	1	1.001124	0.00112
0	-3.997	0	1.17218	0	0	0	0.6688	-0.43115	0.0172	0	-9.15991	-11.729	0.000008052	1	1.000008	0.00001
0	-3.426	3.3552	1.75827	0	0	0	0.5351	-0.43115	0.043	3.67504	-9.15991	-3.650	0.025983668	1	1.025984	0.02533
0	-3.997	3.3552	2.93044	0	0	0	0.4013	-0.43115	0.0086	0	-9.15991	-6.892	0.001015636	1	1.001016	0.00101
0	-	0	2.6374	0	1.16101	4.0853	0.936	-	0.017	0	-	-4.179	0.015305994	1	1.01530	0.01508

	3.426						4	0.43115	2		9.15991				6	
0	-3.997	0	2.05131	0	0	0	0.8026	-0.43115	0.043	0	-9.15991	-10.69	0.000022751	1	1.000023	0.00002
0	-2.141	3.3552	1.17218	0.35498	1.16101	4.0853	0.0669	-0.43115	0.0172	0	-9.15991	-1.5194	0.218843673	1	1.218844	0.17955
0	-3.426	3.3552	2.34435	0.35498	0	4.0853	0.5351	-0.43115	0.043	0	-9.15991	-2.298	0.100366830	1	1.100367	0.09121
0	-2.141	3.3552	2.34435	0	1.16101	0	0.6688	-0.43115	0.1547	3.67504	-9.15991	-0.373	0.688619197	1	1.688619	0.40780
0	-2.141	3.3552	2.34435	0.35498	1.16101	0	0.2675	-0.43115	0.0687	3.67504	-9.15991	-0.505	0.603316285	1	1.603316	0.37629
0	-3.426	0	3.22349	0	1.16101	4.0853	0.6688	-0.43115	0.0086	3.67504	-9.15991	-0.194	0.823241115	1	1.823241	0.45153
0	-2.141	0	1.17218	0	1.16101	4.0853	1.2039	-0.43115	0.0086	0	-9.15991	-4.101	0.016553678	1	1.016554	0.01628
0	-	0	2.3443	0	0	0	0.133	-	0.025	3.6750	-	-6.837	0.001072402	1	1.00107	0.00107

	3.426		5				8	0.43115	8	4	9.15991				2	
0	-3.426	0	2.05131	0	0	0	0.5351	-0.43115	0.0258	0	-9.15991	-10.40	0.000030292	1	1.00003	0.00003
0	-2.141	3.3552	1.46522	0	0	0	0.4013	0	0.0086	3.67504	-9.15991	-2.395	0.091111354	1	1.091111	0.08350
0	-2.141	0	2.34435	0	0	0	0.8026	-0.43115	0.0172	3.67504	-9.15991	-4.892	0.007499071	1	1.007499	0.00744
0	-2.141	0	2.05131	0	0	0	0.2675	0	0.0086	0	-9.15991	-8.973	0.000126716	1	1.000127	0.00013
0	-3.426	3.3552	1.46522	0	0	0	0.5351	-0.43115	0.0258	3.67504	-9.15991	-3.960	0.019053252	1	1.019053	0.01870
0	-2.141	3.3552	1.46522	0	0	0	0.4013	-0.43115	0.0687	3.67504	-9.15991	-2.7666	0.062871196	1	1.062871	0.05915
0	-3.426	3.3552	2.05131	0	0	0	0.2675	-0.43115	0.043	3.67504	-9.15991	-3.6247	0.026655185	1	1.026655	0.02596
0	-	3.3552	1.7582	0	1.16101	4.0853	1.070	-	0.043	0	-	-1.5439	0.213541582	1	1.21354	0.17597

	3.426		7				1	0.43115			9.15991				2	
0	-3.997	0	0.87913	0	0	0	0.4013	-0.43115	0.0602	3.67504	-9.15991	-8.5721	0.000189309	1	1.000189	0.00019
0	-3.426	0	3.22349	0	0	0	0.4013	-0.43115	0.0516	0	-9.15991	-9.340	0.000087800	1	1.000088	0.00009
0	-3.997	0	2.6374	0	0	0	0.2675	-0.43115	0.0258	0	-9.15991	-10.657	0.000023535	1	1.000024	0.00002
0	-2.141	0	1.46522	0.35498	0	0	0.2675	-0.43115	0.0258	3.67504	-9.15991	-5.9436	0.002622582	1	1.002623	0.00262
0	-2.141	0	1.75827	0.35498	0	0	0.2675	-0.43115	0.0258	3.67504	-9.15991	-5.6505	0.003515577	1	1.003516	0.00350
0	-2.141	3.3552	0.87913	0.35498	0	0	0.4013	-0.43115	0.043	3.67504	-9.15991	-3.0235	0.048627909	1	1.048628	0.04637
															$\sum P_i$	=35.99944

Source: Field Survey, August 2008.