DISSEMINATION AND ADOPTION OF IMPROVED FODDER TREES: THE CASE OF CALLIANDRA CALOTHYRSUS IN EMBU DISTRICT, KENYA

By

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A thesis submitted to the University of Nairobi in partial fulfilment of the requirements for the degree of Master of Science in Agricultural Economics

2001
DECLARATION

This thesis is my original work and has not been submitted for any degree in this or any other university.

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LIST OF ACRONYMS AND ABBREVIATIONS

AI = artificial insemination

CBO = Community Based Organization

C.P = crude protein

DAREP = Dry Land Applied Research and Extension Project

ECF = East Coast Fever

FAO = Food and Agriculture Organisation

FHH = Female-Headed Households

FMF = Female Managed Farms

ICRAF = International Centre for Research in Agro-forestry

IFAD = International Fund for Agricultural Development

IFPRI = International Food Policy Research Institute

ILRI = International Livestock Research Institute

JMF = Jointly Managed Farms

KARI = Kenya Agricultural Research Institute

KCC = Kenya Co-operative Creameries

KEFRI = Kenya Forestry Research Institute
LR = Log-likelihood Ratio

LRI = Likelihood Ratio Index

MHH = Male-Headed Households

MMF = Male Managed Farms

MoALDM = Ministry of Agriculture, Livestock Development and Marketing

MT = Metric tons

NARP = National Agro-forestry Research Project

NDDP = National Dairy Development Project

OLS = Ordinary Least Squares

PRA = Participatory Rural Appraisal

RRC = Regional Research Center

SSA = Sub-Saharan Africa

T&V = Training and Visit

UNDP = United Nation Development Program
This study assessed the effectiveness of different extension methods in reaching farmers in different gender categories of dairy farms to inform them about *Calliandra calothyrsus* fodder trees technology and also factors determining adoption. Data was collected on 300 randomly selected farm households in Embu. The sample households were gender disaggregated at two levels, first, according to the gender of the household head and then on the basis of gender of dairy enterprise manager. Based on gender of the household head, male-headed households (MHH) and female-headed households (FHH) were distinguished. Household categories by gender of the dairy enterprise manager comprised of male managed farms (MMF), female managed farms (FMF), and jointly managed farms (JMF). Descriptive statistics were used to in the assessment of the effectiveness of dissemination methods while for adoption analysis, Tobit analysis was used. Recommendations were then made on how calliandra dissemination and adoption can be enhanced.

Use of formal methods of extension (on farm trials, farm visits, field days and demonstrations) was ineffective in reaching many farmers and was often biased against women. Field days and demonstrations where information on calliandra was disseminated had reached the highest number of farmers, which was only 19 percent. Only 8 percent of farmers in the FHH had attended field days and demonstrations compared to 20 percent in MHH. It was also found that during farm visits extension agents often delivered messages about the technology to men alone even in cases where dairy was co-managed by husband and wife. Although only a few sample farms had participated in the on-farm trials on calliandra (3 percent) none of them was a FHH. Use of women groups enabled relatively
more women to be reached but the groups lacked modalities on production of own calliandra planting materials (seedlings) as initially intended.

Only 16 percent of farmers grew calliandra and the mean number of trees per adopter household was only 80 trees. Less of the FHH (11 percent) than MHH (17 percent) had calliandra. Adopter FMF and JMF had less trees (40 and 35 respectively) compared to JMF (120 trees). Adoption was significantly and positively influenced by perception that calliandra could enhance productivity, access to extension, and participation in on-farm trials. While lack of a milk market has become an important problem in Embu District following the collapse of the Kenya Co-operative Creameries (KCC), Tobit results using observations for all farmers showed that calliandra adoption increased with the proportion of milk produced that the farmers were able to sell.

From these findings the following recommendations were made: (a) Calliandra dissemination through extension functions such as group demonstrations and extension visits should be intensified because this has a positive impact on adoption. (b) The bias against women in the conventional extension methods should also be addressed through use of methods that are more effective in reaching the women (e.g. use of women groups), including women in farm trials on the technology, ensuring that extension activities are always held in times and places convenient for women to attend and training and encouraging extension agents to convey extension messages to both men and women during farm visits. (c) The extension message should have empirical evidence showing the contribution of calliandra to productivity so as to favourably influence farmers’ perception about this and thereby foster adoption. (d) Efficient milk marketing channels should also be developed in the district.
CHAPTER ONE

INTRODUCTION

1.1 Background

1.1.1 Importance, Structure and Challenges in the Kenyan Dairy Industry

Dairy production is one of the major sub-sectors of Kenya’s agricultural sector. Milk, the main product of dairying, has been described by Berg (1990) as an excellent food for human beings, which by virtue of its high nutritive value, offers a great potential in combating malnutrition. Milk also plays a major role as a “cash crop” whereby it ensures a regular source of income especially to majority of smallholder farmers in Kenya (Rey et al, 1993). Beyond the farm, the dairy industry contributes to Kenya’s economy by creating employment in processing and distribution of dairy products (Kenya Government, 1997). In addition, dairy production through the plant-animal-soil interactions plays a key role in enhancing productivity and sustainability of crop-based smallholder farming systems (Winrock International, 1984).

Literature on the history of commercial dairy farming in Kenya shows that there have been major structural changes in the industry since independence. At independence, commercial dairying was the domain of large-scale farmers (FAO, 1986). However, a steady increase in participation of smallholder
farmers in the industry has been witnessed since then. By the 1980's, smallholder farmers accounted for the largest portion of the country's total dairy production (Kenya Government, 1986). In 1999 it was estimated that about 70 percent of the marketed milk in Kenya was produced by smallholder farmers (Omore, et al, 1999).

The government's policy objective in dairy production is attainment of national self-sufficiency and surplus for export (Kenya Government, 1986; 1994). The main challenges to the realization of this objective is the country's high population growth rate and the consequent rapid increase in domestic demand for milk and milk products paralleled by declining per capita agricultural land area. Besides, a change in people's dietary habits, which has accompanied urbanization, has also played an important role in increasing the national demand for milk. It is projected that by the year 2010 the demand for milk in Kenya will rise to about 5.8 billion metric tons (MT) which is 15 percent higher than the projected supply of about 5 billion MT (ILRI, KARI and MoALDM, 1996). The need to ameliorate this situation calls for generation and utilization of technologies that can facilitate both the intensification and long run sustainability of production in dairy.

Over the last decade there has been increasing recognition of the crucial role women play in agriculture and by extension in dairy in Sub-Saharan Africa. The out migration of men from rural areas in search of better paying off-farm employment has resulted in an increase in the number of farm enterprises
managed by women. Introduction of cash crops in African agriculture has also led to an increase in workloads in the farms forcing women to take up activities that were traditionally done by men. In Kenya, it has been estimated that women manage 40% of the smallholder farms and provide about 75% of the agricultural work force (World Bank, 1990). In the smallholder dairy subsector in particular, Maarse (1995) indicated that women provided most of the labour in the “zero-grazing”1 dairy production system. Women especially did most of the work in cutting grass, manure application, feeding animals, general cleaning, milking, fetching water, heat detection, and selling milk.

Despite the dominant role of women in agriculture, agricultural development projects have tended to be biased against them. A case in point is the work by the National Dairy Development Project (NDDP) in its early stages of getting farmers to adopt the “zero” grazing technology package. Evaluating the project in 1995, Maarse observed that messages about the technology were mainly disseminated to men while women were ignored. She also found that the project had disregarded the fact that adopting the technology entailed readjustments in farming systems including resource use especially labour and a redefinition of gender roles within the household. Given the important role played by women in the dairy sub-sector, effective diffusion of innovations can only be realized if women were better targeted in the dissemination of technologies and their adoption behaviour well understood.

1 “Zero” grazing is a system of dairy production where animals are confined and farmers cut and carry fodder to them.
1.1.2 Generation and Utilisation of Dairy Production Technologies in Kenya

Some remarkable achievements in generation, diffusion and utilization of improved dairy technologies have been realized in Kenya. Specifically, breeding programs by researchers, successful promotion of artificial insemination (AI) by extension agents and use of the service by farmers have greatly contributed to the improvement of the national dairy herd that has been realized since independence (MoALDM, 1990). Likewise, use of vaccines and acaricides has greatly enhanced control of some fatal livestock diseases such as East Coast Fever (ECF). This has in-turn facilitated the spread of dairy production to areas where, hitherto, livestock production was not possible. Another important innovation in dairy production in Kenya has been the zero-grazing technology package. Widespread adoption of all or some of the aspects of the package led to massive increases in production and productivity in dairy in the 1980’s (MoALDM, 1990). Increasing national demand for milk and the need to release more land for competing agricultural activities in smallholder mixed farms has, however, meant that it is important to continue striving for improvements in dairy productivity.

In spite of the impressive record on generation and utilization of improved animals and “zero” grazing technologies in the Kenyan dairy industry, research findings indicate that because of poor quality and inadequate feed resources, smallholder farmers realize much less milk per animal than large-
scale farmers (MoALDM, 1990; Omore 1994)). The problems of poor quality and inadequate feed resources tend to be most severe in the dry season when most grasses dry up and re-growth and protein contents of the fodder plants are very low (MoALDM, undated). For smallholder farmers, use of commercial feeds to supplement the animals’ nutrient requirements is constrained by the high costs of the feeds and the farmers’ lack of financial resources. In response to these problems, scientists have researched on and tried to promote use of improved fodder trees such as Calliandra calothyrsus as cheaper alternatives of improving animal nourishment and productivity in smallholder dairy.

The calliandra fodder trees are reputed for the high amount of protein they can provide to livestock fed on low quality roughage or grasses like napier (Pennisetum purpureum). In Kenya, feeding trials have confirmed calliandra’s effectiveness both as a supplement to dairy animals’ basal diet and as a substitute for dairy meal. One kilogram (kg) dry calliandra (24% crude protein (C.P) and 69% digestibility when fed fresh) has the same amount of digestible protein as 1kg dairy meal (16% C.P and 80% digestibility) (Paterson, et al 1996). Since 1kg dry calliandra is the equivalent of 3kg fresh calliandra, 3kg fresh calliandra can replace 1kg of dairy meal without affecting productivity. An additional 1kg of dry calliandra increases milk production by 0.6 kg, the same increment that is obtained from an additional 1 kg of dairy meal. As an added advantage, calliandra increases the butter fat
content of milk (KARI and ICRAF, 1998; Lodoem, 1998).

Unlike most conventional fodders and forages, improved fodder trees such as calliandra have deep rooting systems that enable them to utilize moisture from deep in the soil and therefore remain green and nutritious in the dry season. The fodder trees also contribute to the sustainability of agricultural production systems through improvement in soil fertility by providing green mulch and nitrogen fixation. They also provide firewood, shade, shelter and building materials (MoALDM, undated). Because most farmers in the Kenya are smallholders, adoption of these trees can greatly improve land use intensity (MoALDM, undated).

Due to the limited size of farms in the high lands of central Kenya, the focus has been to integrate calliandra into the existing farming systems rather than planting it on pure stand fodder banks. The fodder tree can be planted as hedges in external and internal boundaries, around the homestead, along soil conservation structures and under Grevillea robusta trees. The fodder trees can also be inter-cropped with napier at a planting arrangement of one row of calliandra to two rows of napier (KARI and ICRAF, 1998; Lodoem, 1998; ICRAF, 1998).

1.1.3 Dairy Farming in Embu District

Dairy production is the dominant livestock production enterprise in Embu District. It is estimated that over 80 percent of farmers in the district own
dairy cows. Most of the milk is consumed at home while some is sold to earn cash to improve the living standards of the farm families (Lodoem, 1998).

Table 1 gives the total numbers of various kinds of animals kept by farmers in the district from 1994 to 1999. Throughout the five years the number of dairy cows was higher than that of any other kind of livestock. Moreover, the number of dairy cows increased from a total of about 56,600 in 1994 to over 63,000 in 1999.

Table 1: Types of livestock kept in Embu District

<table>
<thead>
<tr>
<th>Year</th>
<th>Type of livestock</th>
<th>1994</th>
<th>1995</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dairy cattle</td>
<td>56,618</td>
<td>62,280</td>
<td>61,257</td>
<td>61,240</td>
<td>63,280</td>
</tr>
<tr>
<td></td>
<td>Beef cattle</td>
<td>9,255</td>
<td>10,180</td>
<td>5,983</td>
<td>5,600</td>
<td>5,100</td>
</tr>
<tr>
<td></td>
<td>Meat goats</td>
<td>35,463</td>
<td>39,009</td>
<td>3,2979</td>
<td>30,650</td>
<td>27,860</td>
</tr>
<tr>
<td></td>
<td>Dairy goats</td>
<td>590</td>
<td>708</td>
<td>2,762</td>
<td>2,900</td>
<td>3,500</td>
</tr>
<tr>
<td></td>
<td>Pigs</td>
<td>1,643</td>
<td>1,808</td>
<td>2,524</td>
<td>2,100</td>
<td>2,490</td>
</tr>
<tr>
<td></td>
<td>Hair sheep</td>
<td>14,179</td>
<td>15,597</td>
<td>12,203</td>
<td>12,310</td>
<td>9,800</td>
</tr>
<tr>
<td></td>
<td>Rabbits</td>
<td>6,918</td>
<td>7,610</td>
<td>8,932</td>
<td>7,580</td>
<td>8,100</td>
</tr>
</tbody>
</table>

Source: MoALDM (1994 -1999)

1.2 Problem statement

In Embu District, it has been established that shortage and poor quality of fodder and pasture, high cost and low quality of concentrates are the major constraints to improvement of production and productivity in the smallholder dairy (MoALDM, 1996, 1997; Lodoem, 1998). In response to these problems, scientists have carried out research to identify less costly alternative sources of quality feeds that farmers could use to supplement the protein requirements.
of their animals. These efforts culminated in the identification of *Calliandra callothyrsus* as a fodder tree that can be grown on farms and used as a low cost substitute for commercial dairy meal (Lodoem, 1998). Subsequently, there have been efforts by institutions like KARI, NDDP, NARP and MoALDM to popularize the fodder tree principally among the smallholder dairy farmers in the district. Only one descriptive study by Franzel, *et al* (1996) has tried to assess whether these institutions’ efforts to diffuse the fodder tree are meeting with any success. The study, however, was limited to only those farmers who had participated on some on-farm calliandra trials conducted by NARP, KARI and KEFRI. Information on how the general farming community is taking up the technology is therefore lacking. There is therefore a need to conduct another study to assess how farmers in the district (especially the smallholder farmers) are taking up the technology.

In Kenya women dominate the smallholder agricultural sector and thus by extension the smallholder dairy sub-sector. In spite of this, conventional methods of agricultural extension have traditionally tended to be biased towards men, while ignoring women (Saito and Weidermann, 1990; Saito *et al.*, 1994; Kimenye, 1998). Recently, there has been an increasing realization that to improve the country’s agricultural sector and household food security, women must be the centerpieces of agricultural development strategies. Consequently, alternative extension methods such as farmers’ networks (e.g. women groups) are increasingly being used in efforts to foster more effective
dissemination of agricultural technologies. It is important to determine how effective these farmer’s networks and other extension methods are in disseminating the improved fodder tree technology to farmers.

For farmers to adopt any technology, it must be suited to their needs and circumstances. Despite the dominance of women in Kenyan agriculture, not much is known about their adoption behavior because most adoption studies have failed to incorporate gender in the analyses. To come up with strategies that offer the greatest potential in enhancing calliandra adoption by men and women farmers in smallholder dairy, it is important to understand the factors that influence the up take of the technology by these farmers. The purpose of this study was, therefore, to carry out gender differentiated analyses of the effectiveness of various dissemination methods and the determinants of adoption behaviour of small-scale farmers in Embu District.

1.3 Objectives and Hypotheses of the Study

1.3.1 Broad Objective

The broad objective of this study was to assess the effectiveness of various extension methods in informing men and women farmers about the improved fodder trees and to explain the adoption behaviour of men and women farmers. It was hoped that findings from this study could be useful in generating recommendations on strategies that could foster diffusion and adoption of calliandra and other farming technologies not only in Embu
District but also in other parts of Kenya.

1.3.2 Specific Objectives

(i) To determine the effectiveness of various extension methods used in the dissemination of information about calliandra in reaching different gender categories of smallholder dairy farmers, that is, farmers in different farm-households by gender of household head and also by gender of farm manager.

(ii) To assess farmers' awareness of recommended practices in the utilization of the technology.

(iii) To assess whether there is a difference in the levels of adoption of calliandra by farmers in different gender categories of dairy farms.

(iv) To determine the factors that influence the probability and intensity of adoption of calliandra fodder trees by farmers in alternate gender categories of dairy farms.

1.3.3 Hypotheses of the Study

To realize the four specific objectives, five hypotheses were evaluated in this study. These were:

(i) There are no differences in the extent to which farmers are reached through the different extension methods used in the dissemination
of information about calliandra in the different gender categories of farm households.

(ii) There are no significant differences in the proportions of farmers that are aware about the existence of the calliandra fodder tree technology among different gender categories of farm households.

(iii) Calliandra adopter farmers are aware of the various technical recommendations on the appropriate utilization of the fodder tree technology.

(iv) There is no significant difference in levels of calliandra adoption across the different gender categories of dairy farms.

(v) None of the characteristics of farms and farmers and also attributes specific to calliandra technology have significant effects on the adoption of the fodder trees in the different gender categories of farm households.

1.4 Justification of the study

Improved technologies have played an important role in revolutionizing agriculture in developed countries and recently in East Asia. However, improved agricultural technologies by themselves cannot increase productivity or improve the standards of living of people unless farmers (both men and women) adopt them. An understanding of the effectiveness of
various dissemination methods in the delivery of the improved technologies and also the factors that determine adoption of these technologies by farmers is a prerequisite in the formulation of strategies that can foster efficiency in the diffusion of these technologies. For the case of calliandra, the improvement in dairy productivity that can be realized if farmers took up the technology can lead to improved standards of living for thousands of people in Embu District. At one level, improved milk supply can aid in the realization of food security for those farm families who are not in commercial dairy production (ICRAF, 1998). At another level, adoption of calliandra fodder trees can increase profitability for farmers in commercial dairy production (Franzel et al., 1996).

Literature on adoption behavior of women is scarce because most studies have in the past failed to incorporate gender into their analysis. Because this study is gender based, it adds to the stock of gender-based studies in the country. It also acts as an indicator of the importance of including gender in future studies. This is important in coming up with recommendations that are based on sound research.

1.5 Study Area

Embu is one of the 12 administrative Districts of the Eastern Province of Kenya. It is bordered by Mbeere District to the east and southeast, Kirinyaga District to the west, and Tharaka-Nithi District to the north. It lies approximately $0^0 8''$ and $0^0 35''$ south and $37^0 19''$ and $37^0 42''$ east.
The district covers an area of 708 square kilometers and is sub-divided into 5 administrative divisions i.e. Manyatta, Runyenjes, Nembure, Kyeni, and Central.

This study was conducted in Runyenjes and Manyatta divisions, which cover a portion of the district where smallholder dairy is a major component of the land use system. The two divisions fall within the coffee-based system, which ranges in altitude from 1300m to 1800m above sea level. It is a high potential area with a bimodal pattern of rainfall. The long rainy season occurs between March and June while the short one occurs between October and December. The average annual rainfall is about 1300mm. Temperatures range from a minimum of 12°c in July to a maximum of 27.1°c in March. The soils are fertile (humic nitisols) and are derived from basic volcanic rocks. The population density is high and ranges from 450 – 700 persons per km² (ICRAF, 1995). Coffee and tea are the major cash crops grown in the area. The main staple foods grown are maize and beans (often inter-cropped), Irish potatoes and bananas. Most farmers in the two divisions are currently paying more attention to dairy as coffee revenues decline.
CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter starts with a review of literature on the need to incorporate gender in agricultural research and extension in section 2.1. Gender based dissemination studies that have been done in Kenya are then reviewed in section 2.2 to identify gaps and also assess the need for the current study. Conceptual issues in adoption of technologies are discussed in section 2.3 followed by a review of the empirical models that have been used to analyse adoption in section 2.4.

2.2 Gender and Agricultural Research and Extension

There has been increasing realisation of the important role women play in agriculture in Africa. It has also been realised that marginalisation of women farmers contributes to poor agricultural productivity and poverty (Self help Development International, undated). Women face formidable constraints in agriculture including disadvantaged access to productive resources and institutional support services. In most African communities women experience difficulties in accessing land because land is inherited patrilineally (IFAD, 2001). Although tenure rules often allow for anybody to own land, women lack the financial resource to buy it (World Bank, 2000). Women also
find it difficult to access formal credit due to lack of collateral and also information on the availability of the credit owing to their low levels of education (IFAD, 2001). The marginalisation of women farmers is compounded by the gender neutrality of policies and institutions in most countries (Chidmenza, 2000; UNDP et al, undated). As discussed later in this review, agricultural research and extension institutions have tended to neglect women in technology generation and dissemination (Self help Development International, undated).

Owing to the disadvantaged position of women farmers, there has been a clamour for incorporation of gender in agricultural research and extension in an attempt to make the research and extension more client-oriented and effective. It has been observed that despite a history of success in generation of improved farming technologies in some countries such as Kenya, yield levels have continued to be low as farmers have failed to adopt the technologies (Kooijman and Mbaru, 1998). Given this situation, scientists have in self-reflection started to question some of the assumptions that underlie their works. One such assumption is the traditional practice of taking households as the basic units of analysis and male heads of households as the principal makers of decisions while roles of other household members are ignored. As Feldstein et al (1990) have observed, the assumption may be flawed because in practice households are complex institutions within which members may do different things, have access to different resources and
benefits and have different responsibilities. Although the household head may solely make some decisions, in most of the cases there are consultations between some or all of the household members. There are also cases where the household members have wholly separate spheres of decision making with reference to production, income and expenditures. With this realization, Feldstein et al (op. cit.) pointed out that productivity and efficiency in agriculture could only be enhanced if those people who make decisions or are actually engaged in production tasks are targeted in technology development and delivery. At the inter-household level, different gender structures, for example, male-headed and female-headed households may represent different research and recommendation domains.

The observations and arguments by Feldstein et al (1990.) form the basis for the special emphasis that was attached to gender in the conceptualisation of the current study. It was recognized that within a household, household dynamics could have important implications on men and women’s access to calliandra extension information, planting material and other inputs associated with the technology and thus ultimately on adoption of the fodder trees. Some differences in access to extension information, adoption of the fodder trees and the influence of various factors on adoption were also anticipated to exist between different gender categories of households. Consequently, the current study set out to investigate these issues.

Household dynamics refers to the relationship between men and women in terms of roles, responsibilities, access to resources and benefits within the households.
Kimenye (1998) and Saito et al (1990) have also advocated for gender sensitivity in agricultural research and extension. Kimenye (1998) observed that there is a need for more farmer (men and women) participation in later stages of technology development and evaluation. She argued that the participation could bring about better incorporation of both men and women farmers concerns in the technology development and therefore enhance adoption.

Saito et al (1990) observed that in Sub-Saharan Africa (SSA), conventional methods of agricultural extension have traditionally tended to be geared towards men while ignoring women. They noted that the bias against women is manifested in the delivery of the extension message itself. The message is generally provided by male extension agents to men with the implicit assumption that it will “trickle across” to women. Citing evidence from Malawi they found out that the “trickle across” does not happen.

Saito et al (1990) also noted that in SSA extension messages tend to focus on activities of male farmers while ignoring the wide rage of agricultural activities, responsibilities and constraints facing women farmers. They pointed out that discrimination against women in agricultural technology generation and dissemination inevitably leads to inefficient use of resources (as women fail to adopt improved technologies) and sub-optimal levels of

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4 Saito et al, (1990) gives an example of a case in Malawi where wives of agricultural extension group members said that their husbands rarely passed the advice to them and when they did, the women had difficulties in understanding the second hand information or did not find it relevant to their needs.
agricultural production. Supporting the same arguments, Saito et al, (1994) reported that in Kenya, women suffer a 20 percent loss in agricultural output due to lack of access to agricultural inputs and support services including extension services.

Given the important role that women play in agriculture in SSA, Saito et al, (1990) argued that there is a need to design extension services that are effective in helping women. Bearing in mind the constraints faced by women farmers in the region, they proposed a number of methods that can be tried. These include use of female extension agents to provide extension services to women, retraining of male extension agents so that they can work with women, gender targeting, use of female farmers’ groups, use of women contact farmers, residential training for women, use of mobile training courses and mass media.

In Kenya, some of the extension methods proposed by Saito et al (1990) are currently being tried. These include use of women home economics workers to provide agricultural extension information to women, use of women contact groups and mixed farmer groups and recruitment of women contact farmers. In Embu District in particular, these methods have been used in the dissemination of the *calliandra calothyrsus* fodder trees. Before the current study, no study had been done to determine whether the methods are meeting with any success. The importance of this study therefore derives from the fact that efficiency in the delivery of the fodder tree technology can be enhanced if
the most effective methods are identified and widely used. It is also important to know the flaws that the less effective methods may be having so that they could be improved.

2.2 Gender Based Dissemination Studies in Kenya

Although literature on gender and dissemination of technologies is scarce, a handful of studies have been done in Kenya. Some of these include works by Mwangi (1988), Hassan and Salasya (1998) and Kimenye (1998).

In her study entitled “Women’s access to agricultural production inputs in Murang’a District, Kenya”, Mwangi (1988) carried out an assessment of women’s access to agricultural extension information. She considered two gender categories of households, that is, female headed households and jointly headed households. Female headed households were defined as those households “where women were in charge because husbands lived away from the farms and only went home periodically, usually at the end of the month or where women were divorced, windowed or not married”. On the other hand, she defined jointly headed households as those ones where the husband and the wife were resident at the farm on a regular basis.

Results by Mwangi (1988) indicated that for the training and visit system of agriculture extension (T&V), attendance levels to demonstrations organized in the farms of contact farmers were very low and that significantly fewer farmers in female managed farms attended the functions than in jointly
managed farms. However, she found that in almost all of the jointly managed farms where farmers had attended the demonstrations (95 percent), it was women who had attended. Consequently, she concluded that the T&V system of agricultural extension had managed to break the barriers against women in agricultural extension dissemination by making them the main extension clientele.

Mwangi’s (1988) conclusion that the T&V system of extension had broken the barriers to provision of extension to women appears faulty because of the very low levels of attendance to the T&V extension functions and the fact that the situation was worse in female headed households. As shown later in this review, the conclusion contradicts findings by Kimenye (1998) and Hassan and Salasya (1998) and there is therefore a need for further investigation. In addition, the female managed households in Mwangi’s (1988) study were never disaggregated into *de jure* and *de facto* female managed farm households for further analysis. Women farmers in *de jure* and *de facto* female managed farms may have differential access to farming resources/inputs which may lead to differences in their constraints and initiatives in accessing agricultural extension. Specifically, women farmers in *de facto* female managed farms may be in a better position to afford agricultural inputs because of financial remittances from their spouses. In comparison, inability to hire labour due to cash constraint may result in heavy

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5 Households where women were widowed, divorced or single mothers
6 Farm households where women are in charge because husbands work and live outside the farms.
workloads for women farmers in the *de jure* female managed farms and therefore lack of time to attend extension functions. Also, extension officers may prefer to have a *de facto* rather than a *de jure* female manager as a contact farmer because the former may have a better financial capacity to implement the recommendations they may prescribe. As a result, the current study separated all these types of households in an attempt to carry out a more exhaustive investigation of women’s access to extension.

Hassan and Salasya, (1998) conducted an analysis of the influence of gender in maize farming and technology transfer in Kenya. Their findings indicated that men enjoyed a better access to production resources than women did. In the dissemination of technologies, they found that fewer women than men were reached before and after the introduction of the T&V system of extension implying that the new system maintained the initial bias against women. In spite of the bias, they found that women applied the improved maize technologies (improved seeds and fertilizers) at the same rate as men meaning that women were highly prepared to take up new technologies. In addition to the preparedness of women to adopt innovations, Hassan and Salasya (1998) also concluded that other sources of agricultural extension like seed dealers and other farmers were playing an important role in the transfer of the maize technologies.

There are numerous differences between the study by Hassan and Salasya (1998) and the current one. First, Hassan and Salasya’s study focused on
dissemination of technologies in maize while the current study focused on calliandra fodder trees. There could be differences in the effectiveness of the dissemination methods in the diffusion of these different types of technologies and therefore the current study hoped to shed light on this. Second, Hassan and Salasya (1998) used the same categorization of farms as Mwangi (1988) whereby farms were categorized into male and female managed farms. In contrast, farm households in the current study were first categorized into male and female headed followed by a further categorization into male, female, and jointly managed farms. In addition, the assessment of effectiveness of extension information dissemination by Hassan and Salasya (1998) did not include methods of extension such as women groups and mixed farmers' groups, farm trials, field days and demonstrations all of which were considered in the current study.

Kimenye, (1998) carried out a study on technology transfer from the Embu Regional Research Center (RRC-Embu) to farmers in Embu and Mbeere districts. She found that the contact farmer method of extension, field days and demonstrations were not effective in reaching farmers. In addition, she found that the three extension methods were significantly biased in favour of men. In particular, her findings indicated that households headed by men enjoyed more frequent extension farm visits than households headed by women and that more women than men failed to attend field days and demonstrations. Women attributed their non-attendance of field days and
demonstrations to the fact that the functions were held far away from their homes and at times when they were busy with other domestic chores. Ultimately, she found that more women than men tended to be unaware of new farming technologies.

The main difference between Kimenye's study and the current one is that the former evaluated the different technology dissemination methods without isolating the diffusion of calliandra fodder tree technology. Her study's findings can therefore be considered general for all technologies and not specific and comprehensive enough for calliandra fodder trees dissemination. For instance, her study did not evaluate the level of awareness about the existence of the calliandra fodder trees among all farmers, that is, adopters and non-adopters. For a conclusive evaluation of the effectiveness of extension methods in the dissemination of calliandra fodder trees technology, information about the levels of awareness of the existence of the technology is needed. One of the objectives of the current study was to generate such information.

2.3 Theoretical Issues in Adoption of Technologies

Three main paradigms have been advanced to explain farmers' adoption decisions (Adesina and Zinnah, 1990). The first paradigm is the innovation-diffusion model, which follows from the classical works of Rogers (1962) (Adesina and Zinnah, 1990). It holds that access to information about innovations is the key factor determining adoption decisions. The paradigm
takes the appropriateness of innovations as given and reduces the problem of adoption to one of communicating information about technologies to potential end users. It emphasizes the use of extension, mass media, local opinion leaders, experiment station visits and on-farm trials to convince the 'sceptic' non-adopters the rationality of adopting.

The second paradigm is the economic constraint model. It contends that economic constraints reflected in the asymmetrical distribution patterns of the factors of production are the major determinants of adoption. As a result, lack of access to capital and land presents some of the most important factors that can constrain adoption of improved technologies by farmers.

The major problem of the innovation-diffusion and the economic constraint paradigms is their inherent weaknesses in sufficiently explaining adoption behaviour and thus in guiding formulation of strategies for accelerating adoption of technical innovations by farmers. As Leagans (1979) observed, adoption behaviour is a complex phenomenon because it is jointly influenced by the state of mind of the farmers, that is, personal (internal) factors and also environmental (external) factors. The personal factors in this context include perceptions of seriousness of problems, attributes of innovations and permissibility of the environment for farmer to use new innovations while environmental factors entail physical environment, economic environment, infrastructure and social environment (Leagans, 1979).
The inadequacy of the innovation-diffusion and the economic constraint paradigms derives from their failure to recognize the important role played by the personal factors in influencing adoption decisions. To address this problem, a third paradigm, that is, adopters' perception paradigm has been advanced. The paradigm holds that farmers' perceptions of attributes of innovations play an important role in conditioning adoption behaviour. As this review later shows, findings by Adesina and Zinnah, (1990), Adesina and Seidi (1995), Adesina and Forson, (1995) and Kimenye (2001) have demonstrated the importance of including perceived attributes of technologies in adoption studies.

The factors emphasized in all the three paradigms have important implications on adoption of improved technologies by farmers. The current study therefore sought to simultaneously include these factors in the assessment of the factors determining the adoption of calliandra fodder trees.

2.4. Analytical models used in adoption studies

When studying adoption, the researcher may be interested in either analysing the effects of various factors on the probability of adoption of a particular innovation or the influence of the factors on both the probability and intensity of use of the innovation. The first scenario depicts a case of a dichotomous discrete choice situation, while the second one involves a case where the
dependent variable has a censored distribution. Censored distribution refers to cases where the dependent variable is only observed in some range (Judge et al., 1988). In adoption studies, although the values of the independent variables are observable for non-adopters, the researcher cannot observe how far from adopting the non-adopters are. The values of the dependent variable are therefore recorded as zeros for non-adopters even though there may be differences in the points where different non-adopters are from adopting. Judge, et al. (1988) have demonstrated why the use of ordinary least squares (OLS) is inappropriate in studying the dichotomous discrete choice kind of situations. They have argued that given a binary choice model (see equation 2.1 below) where Y takes the values of 1 when a particular choice is made and 0 otherwise, numerous difficulties would arise if OLS were used to obtain the parameter estimates.

\[ Y_i = X_i \beta + e_i \quad \text{where } i = 1, \ldots, T \]

\[ Y_i = \text{Dependent variable} \]

\[ \beta = \text{Vector of unknown parameters} \]

\[ e_i = \text{Random error term} \]

Equation 2.1

The first problem relates to the usual assumption in OLS that \( E[Y_i] = X_i \beta \). The Bernoulli character of the dependent variable demands that \( E[Y_i] = \text{Pr } [Y_i] \).
However, given that $X_i\beta$ is not bounded, the model can give probabilities outside the unit interval. Secondly, because $Y_i$ can only take two values, $e_i$ can also only take two values, each with a specified probability;

$$e_i = 1 - X_i\beta \text{ with probability } X_i\beta \text{ when } Y_i = 1 \quad \text{Equation 2.2}$$

$$e_i = X_i\beta \text{ with probability } 1 - X_i\beta \text{ when } Y_i = 0 \quad \text{Equation 2.3}$$

Following this probability structure, $e_i$ is heteroskedastic (Judge et al., op. cit.) and therefore use of OLS would result in inefficient parameter estimates and a biased covariance matrix (Maddala, 1977). For the case where the dependent variable has a censored distribution, Judge et al., (op. cit.) have noted that use of OLS would yield parameter estimates that are inconsistent. Because of these problems, most researchers have resorted to use of qualitative and limited dependent variable models in conducting empirical studies on adoption.

There are two types of qualitative dependent variable models that are popularly used in adoption studies, namely, the probit and the logit models. Essentially, there are no major differences between the two types except that the former assumes a normal distribution for the random term while the latter assumes a logistic distribution (Amemiya, 1981; 1995 and Judge et al., 1988). Studies that have used the logit model include Adesina and Seidi (1995) and Kimenye (2001) while those that have used the probit model include Jha et al (1991).
Adesina and Seidi (1995) used a logit model in their study of farmers’ perceptions and adoption of modern mangrove rice varieties in Guinea-Bissau. Their findings indicated that farmers perception about yield performance of the improved varieties, ease of threshing and shortness of crop cycle were significant in determining adoption. In addition, contact with extension agents and access to non-farm income also significantly influenced adoption.

Kimenye (2001) also used a logit model in her assessment of the factors determining adoption of improved varieties of cowpeas and sorghum by women farmers in Mbeere District, Kenya. Her findings showed that in the case of sorghum varieties, ease of processing significantly influenced adoption while cowpea adoption was significantly influenced by varietal tenderness of leaves, grain yield and taste.

Jha, et al (1991) used the probit model to study the adoption of improved agricultural technologies (fertilizer, improved maize varieties and animal traction) in Eastern province of Zambia. Their findings indicated that the adoption of the technologies was positively influenced by extension, membership to cooperatives and infrastructure and negatively by age. Being a woman farmer also negatively influenced adoption.

When used in adoption studies, the probit and the logit models only give information about adoption probabilities. The two models were therefore not suitable for the current study where the interest was to analyse the effect of
various factors on both the probability and intensity of adoption of calliandra fodder trees. In analysing the effect of different factors on both the probability and intensities of adoption of technologies, a Tobit model has mostly been used. Examples of studies that have used the Tobit model include Adesina and Zinnah (1992), Adesina and Forson (1995), Nkonya et al (1997) and Irungu (1999).

Adesina and Zinnah (1992) used a Tobit model to investigate the effects of the perceived technology attributes on the adoption of improved rice varieties in Sierra Leone. Their model was formulated as follows.

\[
Y_i = X_i \beta \text{ if } I^* = X_i \beta + u_i > T \\
= 0 \text{ if } I^* = X_i \beta + u_i < T
\]

Equation (2.4)

Where,

\( Y_i \) is the probability of adopting and the intensity of adoption of a modern rice variety

\( I^* \) is a non observable latent variable

\( T \) is a non-observable threshold level

\( X_i \) is a n x k matrix of explanatory variables for farmer i and these
included farm, farmer and the technology specific attributes.

$\beta$ is a vector of parameters to be estimated.

Findings by Adesina and Zinnah (1992) showed that farmers' perceptions about the yield performance of the new varieties, ease of cooking, ease of threshing and tillering capacity were the major factors that conditioned adoption of the improved rice varieties.

Adesina and Forson (1995) investigated the adoption of improved sorghum varieties in Burkina Faso and improved rice varieties in Guinea. Their study was a replicate of the study by Adesina and Zinnah (1992) and was aimed at further investigating the findings obtained in the earlier study that farmers' perceptions of technology specific attributes significantly influence adoption. For the improved sorghum varieties, their findings indicated that farmer perception about the yield performance of the varieties, quality of porridge made from sorghum, adaptability to poor soils positively and significantly influenced adoption. In addition, participation in on-farm tests had a positive and significant influence on adoption of the sorghum varieties. For the improved rice varieties they found that perceptions of yield performance, ease of cooking, tillering capacity and ease of threshing had a positive influence on adoption and were the only factors that were significant.

Nkonya et al (1997) used a Tobit model to study the factors affecting the adoption of improved maize seeds and fertilizer in Tanzania. They found that...
adoption of the improved maize seeds was positively and significantly affected by fertilizer use, size of farms, level of education, and contact with extension. For fertilizer, they found that use of improved seeds and size of farms positively and significantly influenced adoption.

Irungu (1999) used a Tobit model to analyse the adoption of napier grass in Kiambu District. He found that farmers' years of experience in farming, size of farms, access to off-farm income, number of livestock units and membership to co-operative societies positively and significantly influenced the probability and intensity of the fodder crop's adoption. The main differences between Irungu's study and the present one is that the two studies focus on different types of fodder crops and they were also done in different regions. In Kenya, use of napier as a basal diet for dairy animals is a relatively older technology than use of calliandra in supplementing the animal's basal diet. Also, Kiambu district where Irungu's study was done is much more peri-urban than Manyatta and Runyenjes divisions of Embu District where the current study was done. There may, therefore be differences in the factors that influence the adoption of napier grass in Kiambu district and those that influence the adoption of calliandra in Embu District. In addition, Irungu's study was not gender based.

A comparison of findings of the various empirical adoption studies reviewed in this study show that the importance of the factors determining adoption varies across technologies and regions. There is therefore a need to conduct
an empirical adoption study that is specific to both calliandra fodder tree technology and Embu District.

In all the adoption studies reviewed here, it was only Kimenye (2001) where gender was used to define the research and recommendation domain. Conversely, all the others failed to do this and included gender only as an explanatory variable in their analysis. As Feldstein (1990) have argued, different gender-structures of households face different resources, constraints and incentives and the structures are therefore important in designing the research and recommendation domains. Consequently, the current study set out to analyse the determinants of calliandra adoption in various gender categories of households.
CHAPTER THREE

METHODOLOGY

3.1 Conceptual framework

This study was conceptualised as a gender based dissemination and adoption study. Farm households were categorized at two levels, first, on the basis of the gender of the household head and then according to the gender of the dairy activity manager, that is, the person in charge of the dairy activity on a daily basis. This method of farm household categorization has also been used by Kimenye (1998) and was adopted in anticipation that there could be some differences in access to extension and in adoption behaviour in different types of women operated dairy farms, that is, *de jure* and *de facto* female managed farms.

In categorising farms by the gender of the household head, male and female-headed farm households were distinguished. Male-headed households (MHH) comprised of households of couples and households where men were widowed, divorced or unmarried. For the households of couples, it was assumed that by African customs, husbands are always the household heads. Female-headed households (FHH) were defined as households where the woman was widowed, divorced or not married (*de jure* female managed farm households).
To categorize the sample farm households by gender of dairy enterprise manager, information was collected on genders' of persons who made decisions on key issues such as planting fodder, buying and selling of animals and use of proceeds from the dairy activity. The categories dairy farms by the gender of dairy activity manager included male, female and jointly managed farms. Male managed farms (MMF) comprised of households where men mainly where men largely made the day-to-day decisions in dairying. Female managed farms (FMF) included the *de jure* female managed farm households and also farm households where women were in charge because their husbands worked and lived outside the farms (*de facto* female managed farm households). Jointly managed farm households (JMF) were those households where both the husband and wife lived in the farm and made most of the farming decisions together⁷.

From literature, adoption behaviour was expected to be a function of farmers characteristics like age and level of formal education, availability of factors of production like land and labour, institutional factors like output markets and farmers groups and access to support services like extension and farmers perception about the technology including the ability of the fodder trees to improve productivity and also quality of milk produced. The adoption

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⁷ It is important to note that in JMF, although there could be consultations between the husband and wife, ultimately the final decision maker may be the man. But to the extent that the man consults the woman before making the decision, it shows that the woman's views are considered before the decision is made unlike in cases where the man would decide on an issue without first consulting the wife, that is, MMF.
behaviour is a limited dependent variable since no values of the variable are observed among the non-adopters.

3.2 Data sources and analyses

This study made use of both primary and secondary data. The secondary data was used in the description of the study area including the farming system, calliandra fodder tree technology and for comparing with results obtained in this study. The sources of the secondary data included publications by research institutions, works by other researchers and government publications.

The primary data in this study was collected using a combination of informal farmer participatory research techniques and formal household surveys. For participatory research techniques, two participatory rural appraisals (PRA's) were conducted, one in Manyatta division and the other in Runyenjes division. Semi-structured interviews were also held with farmer focus groups including women and mixed farmer groups. In addition, there were discussions with key informants from MoALDM who were involved in the dissemination of the fodder tree technology. Information gathered during the PRA'S was used in the preparation of the survey questionnaire. Results from the interviews with focus groups were used in the evaluation of the effectiveness of the groups' approach to technology dissemination.

The main objective of the farm household survey was to collect gender disaggregated data for qualitative and quantitative evaluation of the
effectiveness of the dissemination methods in informing farmers about calliandra and quantitative assessment of the determinants of adoption. The effectiveness of the dissemination methods was determined by comparing the proportions of farmers reached and also the frequency of contact with extension agents through each of the methods across the different gender categories of farm households. For collective effectiveness of the dissemination methods, farmers’ awareness about the existence of the technology and also the various technical recommendations about technology were assessed. In addition, levels of adoption of the technology (frequencies of farmers with calliandra and numbers of trees among adopter farmers) were compared across the gender categories of dairy farms.

The methods used to disseminate the information about calliandra included both conventional and informal approaches of extension. The conventional methods included on-farm trials, farm visits by the extension staff, field days and demonstrations. The informal methods comprised of women and mixed farmers groups and the farmer-to-farmer exchanges. The first hypothesis was rejected for each extension method if the proportion of farmers reached and/or the frequency of contact with the extension agent were qualitatively judged to be very different among the different gender categories of farm households. The second hypothesis was rejected if the proportion of farmers who were aware about calliandra varied greatly across the types of farm households. The third hypothesis was rejected if 50 percent or more of calliandra adopter
farmers were unaware of the appropriate recommendations in calliandra utilisation. The fourth hypothesis was rejected if the proportion of farmers with calliandra and/or the number of calliandra trees per adopter farmers were statistically insignificant across the gender categories of farm households. For adoption analyses, both descriptive statistics and econometric analyses were used. A farmer was regarded a calliandra adopter if he/she had purposely planted at least one fodder tree for use as feed for cattle.

3.3 Sampling techniques for household survey

A two stage sampling procedure was used to select 300 farm households (150 from each division) from whom data was collected. The first sampling stage involved selection of sub-locations in each of the locations in the two study divisions. During the process, the sub-locations in each location were ranked alphabetically. Random numbers were then used to select half the number of the sub-locations in each case. Through this procedure, a total of 8 sub-locations in Manyatta and 7 in Runyenjes were selected.

The second sampling stage involved determining the specific farm households where farmers were to be interviewed in those sub-locations that had been selected during the first stage. To accomplish this, a systematic sampling approach was adopted. This involved, first, drawing maps of the sub-locations with the help of the extension staff. Using the maps, some routes were selected and transects conducted. The selection of transect routes was done in such a way that each of the selected sub-locations was comprehensively
covered. Household managers in every fifth farm on the alternate sides of the selected routes were interviewed. Only farm households with dairy animals were selected. If the fifth farm household was not engaged in dairy production, the interview was conducted in the adjacent one that had the activity.

3.4 Econometric Model

Adoption of improved fodder trees has a censored distribution since the number of trees is zero for non-adopters. In cases like this (where the dependent variable is only observed in some range), the Tobit model can be used to analyse the factors affecting the probability and intensity of adoption of the technology (Tobin, 1958). The probability of adoption is intrinsic in the proportion of calliandra adopter farmers in the whole sample while the intensity of adoption relates to the number of calliandra trees among the adopter farmers.

In the formulation of the Tobit model, farmers' adoption decisions are assumed to be based upon utility maximisation (Rahan and Huffman, 1984 cited by Adesina and Zinnah, 1992). The utility derivable by a farmer from choosing to adopt or not to adopt a given technology is a function of the farm, farmer and technology specific attributes (Adesina and Zinnah, 1992). In effect, the underlying unobservable utility function for the farmer can be written as:

\[ U_i = U(W_i, Z_i) \]  

Equation (3.1)
Where,

\[ U_i = \text{Utility derived by farmer } i. \]
\[ W_i = \text{farm and farmer's characteristics.} \]
\[ Z_i = \text{technology specific attributes as perceived by the farmer.} \]

Following Judge et al. (op. cit.), the equations for the utility derived by the \( i^{th} \) farmer from failing to adopt and adopting the fodder trees can respectively be written as:

Utility from failing to adopt; \( U_{i0} = Z_{i0} \theta + W_i \mu_0 + e_{i0} \) \ (Equation 3.2a)

Utility from Adopting; \( U_{i1} = Z_{i1} \theta + W_i \mu_1 + e_{i1} \) \ (Equation 3.2b)

Where,

\( U_{i0} \) and \( U_{i1} \) are utilities deliverable from not adopting and adopting the improved fodder trees respectively and are random;

\( Z_{i0} \) and \( Z_{i1} \) are vectors of attributes of the old and the new technology, respectively; \( Z_{i0} \) is zero if the farmer was not previously using any technology.

\( W_i \) is the vector of farm and farmer specific attributes; and \( e_{i0} \) and \( e_{i1} \) are random terms.

Subscripts 0 and 1 denote the choice of not adopting and adopting the
improved fodder tree technology, respectively.

Any given farmer (i\textsuperscript{th} farmer) will only adopt the improved fodder trees if $U_{i1} > U_{i0}$ or if the unobservable (latent) random variable $Y_i^* = U_{i1} - U_{i0} > 0$

The expression $Y_i^* = U_{i1} - U_{i0}$ can be rewritten as:

$$Y_i^* = (Z_{i1} - Z_{i0}) \Theta + W_i (\mu_1 - \mu_0) + (e_{i1} - e_{i0})$$

$$= [(Z_{i1} - Z_{i0}), W_i] \begin{bmatrix} \Theta \\ \mu_1 - \mu_0 \end{bmatrix} + V_i$$

$$= X \beta + V_i \quad \text{(Equation 3.3)}$$

Where,

$X$ is a $n' \times K$ matrix of explanatory variables;

$\beta$ is a $K \times 1$ vector of the unknown parameters; and

$V_i$ is a random error term.

Letting $Y_i$ denote the probability and intensity of adoption of the improved fodder tree technology, the Tobit model can be written as:

$$Y_i = X_i \beta \text{ if } Y_i^* = X_i \beta + V_i > C$$

$$= 0 \text{ if } Y_i^* = X_i \beta + V_i < C \quad \text{(Equation 3.4)}$$
Where,

\[ Y_j^* \] is the unobserved latent variable; and

\[ C \] is a non-observed threshold level.

The model assumes that the random error term, \( V_j \), is normally and independently distributed with mean = 0 and constant variance \( \sigma^2 \). If the non-observed latent variable \( Y_j^* \) is greater than \( C \), the observed qualitative variable \( Y_j \), which is indicative of adoption becomes a continuous function of the explanatory variables. On the other hand, if \( Y_j^* \) is less than or equal to \( C \), \( Y_j \) becomes zero meaning that there is no adoption. The Tobit models for the entire sample of farmers and different gender categories of farm households were estimated using the LIMDEP computer package.

Following McDonald and Moffit (1980), the coefficients obtained from the Tobit analysis were decomposed to show the effect of changes of the independent variables in the probability and intensity of adoption. The basic relationship utilised in conducting the decomposition follows from results obtained by Tobin (1958) and Amemiya (1973) and is given as

\[ E (P) = F (Z) * E (p) \] (Equation 3.5)

In the context of adoption, Adesina and Zinnah (1992) have interpreted the terms in the equation as

\[ E (P) = \text{Expected value of the dependent variable across all the observations.} \]
\( E(p) = \) Expected value of the dependent variable given that the farmer is already an adopter and is only concerned about the intensity of using the technology.

\( F(Z) = \) the probability of adoption for those not already using the technology.

To get the effect on adoption behaviour due to a change in any one of the dependent variables, equation 3.5 is differentiated with respect to \( X_j \)

\[
\partial \frac{E(P)}{\partial X_j} = F(Z) \left[ \frac{\partial E(p)}{\partial X_j} \right] + E(p) \left[ \frac{\partial F(Z)}{\partial X_j} \right] \quad (\text{Equation 3.6})
\]

Multiplying through by \( \frac{X_j}{E(P)} \), we get

\[
\left[ \frac{\partial E(P)}{\partial X_j} \right] \frac{X_j}{E(P)} = F(Z) \left[ \frac{\partial E(p)}{\partial X_j} \right] \frac{X_j}{E(P)} + E(p) \left[ \frac{\partial F(Z)}{\partial X_j} \right] \frac{X_j}{F(Z)} \quad (\text{Equation 3.7})
\]

Rearranging equation 3.7 using equation 3.5 whereby \( F(Z) = \frac{E(P)}{E(p)} \) and \( E(p) = \frac{E(P)}{F(Z)} \), we get

\[
\left[ \frac{\partial E(P)}{\partial X_j} \right] \frac{X_j}{E(P)} = \left[ \frac{\partial E(p)}{\partial X_j} \right] \frac{X_j}{E(p)} + \left[ \frac{\partial F(Z)}{\partial X_j} \right] \frac{X_j}{F(Z)} \quad (\text{Equation 3.8})
\]

This implies that total elasticity = Use intensity elasticity + Adoption probability elasticity

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Variables included in the Econometric Model

Dependent variable

The dependent variable was taken to be the total number of calliandra fodder trees per household scaled down by ten (TCAL). The scaling down was in accordance with Greene, (1994) and was necessitated by some convergence problems when the total number of calliandra trees was used.

Independent variables

AGE

Data on age was collected as a continuous variable. As Adesina and Zinnah (1992) have observed, younger farmers tend to be more knowledgeable about new practices and may be more willing to bear risks because of their longer planning horizon. Also, unlike their older counterparts, the younger farmers are more likely to be interested in adopting new technologies because of their comparatively higher need for extra income (Nkonya et al, op. cit.). A negative relationship was therefore hypothesized between the variable AGE and the probability and intensity of calliandra adoption.

Education (EDUCATN)

Data on education was included in the models as a continuous variable, that is, number of years of formal education. Better-educated farmers are more likely to have access to extension services and also to adopt new technologies.
In the innovation-diffusion model, Rogers (1962) has observed that early adopters tend to have more years of education. In this study therefore, education was expected to have had positive influence on the probability and intensity of adoption of the calliandra fodder trees.

**Farm size (FSIZE)**

Land is a basic resource in agricultural production. Smallholder farmers tend to have small pieces of land, which make it favourable for them to adopt technologies like the calliandra fodder tree, which can intensify land use. However, smallholder farmers with relatively bigger pieces of land would have larger niches to allocate to the new technology (Feder and Slade, 1984). Owners of larger farms also tend to have greater financial resources and access to information (Feder and Slade, 1984) and are therefore likely to be less risk-averse because they have a relatively larger capacity to absorb losses, which they may fear could arise from adopting a new technology. For example, fear that the fodder trees may adversely affect other crops may entail a relatively bigger disincentive to adoption for farmers with small farms than in cases where the farms are big. In addition, the smallholder farmers with larger farms may be in a better position to afford (access) inputs that go together with the new technologies. For the case of improved fodder trees, these include inputs such as calliandra seeds and seedlings and labour. It was therefore anticipated that farm size had a positive effect on adoption.
Family labour (FLABOR)

Family labour is the chief form of labour utilized in the small-scale farms. Inadequate labour may constrain farmers from adopting improved agricultural technologies or aspects of these technologies (Maarse, 1995; Maarse, 1998). Adoption of improved fodder trees requires labour for planting and performance of other cultural practices like weeding, manuring and pruning.

In this study, data on family labour was collected as the total number of family members who worked on a regular basis in the farm. A positive relationship between family labour and the probability and intensity of adoption of improved fodder trees was hypothesized.

Index of commercialisation of the dairy enterprise (DCOMMER)

This variable was obtained by dividing the average of the amount of milk sold per day by that produced. Farmers in Embu District are increasingly finding it difficult to market their milk following the collapse of the Kenya Cooperative Creameries (KCC). Most of the farmers are currently dependent on the informal milk market (milk hawkers, neighbours, shops and kiosks) to sell their milk and these are often not able to take all the milk that the farmers are willing to sell. Index of commercialisation is expected to be higher the proportion of milk a given farmer is able to sell. Because of the drive to realize higher profits, calliandra technology adoption was expected to be more likely and intensive the more the dairy enterprise was commercialised.
Membership to calliandra groups (CALG)

Mixed farmer groups and self-help women groups had been used in the diffusion of calliandra fodder tree technology in Embu District. Membership to a calliandra group was included as a dummy variable; it was 1 if the farmer was a member and 0 otherwise. Membership to farmers groups enhances farmers' access to agricultural information including new technologies and external inputs such as seeds (Kimenye, 2001). Being a calliandra group member was therefore expected to have had a positive relationship with adoption.

Extension (EXTN)

Extension was included as a dummy variable, with a value of one for farmers who had received extension farm visits on calliandra or attended agricultural field days or demonstrations where information on calliandra was disseminated and zero otherwise. Extension provides farmers with information about new technologies and has been found to influence adoption of improved maize varieties in Tanzania (Nkonya et al, 1997) and Kenya (Okuro et al, 2000). Thus, a positive relationship between extension and the probability and intensity of adoption of the improved fodder trees was postulated.

Participation in the on-farm trials on calliandra (TRIAL)

This variable was measured as a dummy with a value of 1 if the farmer had
participated in on-farm trials on calliandra and 0 otherwise. The participation in the on-farm trials on the fodder trees gave the participant farmers an extensive access to information about the technology. It also gave them access to initial planting material (seedlings), which they could have multiplied to increase the number of their fodder trees. Consequently, participation in the trials was expected to have had a positive influence on the probability and intensity of adoption.

**Gender of household head (GHHH)**

This variable was also expressed as a dummy, with one if the head of the household was a male and zero otherwise. Given the disadvantaged position of women with respect to access to support services and other inputs, it was expected that MHH would adopt faster than FHH.

**Perceived effect of calliandra on milk production (CALMP)**

This variable was measured as a dummy, one if the farmer thought that calliandra could help improve milk productivity and zero if otherwise. Farmers' perception about the potential embodied in innovations plays a critical role in determining adoption (Lionberger and Paul, 1991). The ability of improved fodder trees to improve milk productivity involves a relative advantage to farmers. It was assumed that farmers are rational, and therefore those who perceived the technology as being able to increase milk productivity were likely to adopt than those who did not have that perception.
The relationship between perception that calliandra could improve productivity and adoption was therefore hypothesized to be positive.

**Perceived effect of calliandra on milk butterfat content (CALMQ)**

Data on this variable was collected as a dummy with 1 if the farmer thought that milk from dairy animals fed on calliandra was richer in butterfat content and 0 otherwise. Research has shown that feeding calliandra can lead to increased butterfat content in milk (KARI and ICRAF, 1998). Milk market in Kenya does not offer a premium for higher butterfat content but farmers were expected to prefer it because they use some of the milk for domestic consumption. As a result, a positive relationship between perception that calliandra could increase butterfat content in milk and adoption was hypothesized.

**Division (DIVISION)**

Division was included as a dummy variable, 1 if the farmer hailed from Manyatta and 0 otherwise. Manyatta Division is wetter than Ruyenjes and dairy production systems in the former are relatively more intensive than the latter. A positive relationship was therefore expected between the variable DIVISION and calliandra adoption.
3.5 Variable screening and model fit tests

3.5.1 Testing for multicollinearity

Multicollinearity refers to a situation where the independent variables exhibit some strong linear relationships among themselves making it difficult to disentangle their individual effects on the dependent variable (Maddala, 1977). Kennedy (1992) has given examples of various sources of multicollinearity. These include cases where the independent variables may share a common time trend or one independent variable may be a lagged value of another that follows a trend. Presence of some approximate linear relationship among regressors and failure to collect economic data from a wide enough base can also lead to the problem of multicollinearity. Since economic data is not generated under experimentally controlled conditions, we can rarely get rid of multicollinearity (Huang, 1964). One tries to minimize the occurrence of the problem. Therefore, the problem of multicollinearity is essentially one of degree rather than existence (Maddala, 1977).

The major undesirable consequence of multicollinearity is the break down of the estimation procedure in cases where there is exact linear relationship between the independent variables. In cases of approximate linear relationships among the independent variables the parameter estimates tend to have very large variances making them not to be precise. Hypothesis testing is rendered impossible because alternative hypothesis about the values of the
parameters cannot be rejected (Kennedy *op. cit.*).

Various ways of detecting the problem of multicollinearity have been suggested but none is self-sufficient. Maddala (1977) has suggested the use of simple correlation coefficients for pairs of independent variables, multiple correlation coefficients of one variable with others, comparison of partial correlation coefficients with the coefficient of determination ($R^2$) and inspection of signs and magnitudes of regression coefficients. He points out that wrong signs and meaningless magnitudes of coefficients and also large changes in the magnitudes and signs of the coefficients when some few observations are omitted may be indicative of a severe problem of multicollinearity. For simple correlation coefficients, Kennedy (1992) suggests that a value of 0.8 or more imply severe collinearity among the affected independent variables. In the current study, the procedures that were used to detect multicollinearity included inspection of signs and magnitudes of the parameter estimates and use of partial correlation coefficients. Appendix i. shows the values of simple correlation for pairs of independent variables included in the Tobit analysis.

### 3.5.2 Testing for heteroscedasticity

One problem often encountered in cross-sectional data is that of heteroscedasticity (Madalla, 1977). This involves variation of the variance of the random term across the observations (Kennedy, 1992). Like in ordinary least square (OLS) estimation, presence of heteroscedasticity in qualitative
response and Tobit models renders parameter estimates inefficient and hence invalid for making predictions about the dependent variable (Green, 1993). A test for heteroscedasticity was therefore carried out using the log-likelihood ratio (LR) method as discussed by Green (1993) and Green (1994). Following Harvey (1976) cited by Green (1994) it was hypothesized that heteroscedasticity of the form $V[e]=e^{\gamma z}$ existed in the data.

Where: $V[e]=$ Variance of the error term

\[ e = \text{error term} \]

\[ \gamma = \text{coefficients in the heteroscedasticity function} \]

\[ z = \text{Variables causing the heteroscedasticity} \]

The test for heteroscedasticity involved testing the hypothesis that $\gamma=0$. To calculate the LR statistic, a restricted Tobit model was first estimated. The restricted model was estimated assuming homoscedasticity, i.e., $\gamma=0$. Then an unrestricted model (i.e., assuming presence of heteroscedasticity) was estimated. The LR statistic was calculated using the formula:

\[ LR = -2 [\ln L_r - \ln L] \]

Where,

\[ \ln L_r = \text{the value of log-likelihood for the restricted model} \]

\[ \ln L = \text{the value of log-likelihood for the unrestricted model} \]

(Equation 3.9)
The LR statistic is asymptotically distributed as a chi-square with degrees of freedom equal to the number of independent variables in the models. Results of these tests are shown in appendix (ii.) and suggest that heteroscedasticity was not a problem in the data set used.

3.5.3 Goodness of fit

Preliminary test for goodness of fit involves an inspection of signs and relative values of coefficients (Ben-Akiva et. al, 1994). In qualitative response and limited dependent variable models, Ben-Akiva 1994 and Green (1993) have recommended the use of the likelihood ratio index (LRI) in the assessment of these models' explanatory power. The LRI is an analogue of the coefficient of determination ($R^2$) in regression analysis and is given by the formula:

$$LRI = 1 - \frac{\ln L}{\ln L_0}$$

Where,

$$\ln L_0 = \text{Log-likelihood function of the model estimated with only the constant term.}$$

$$\ln L = \text{Log-likelihood function of the model estimated with all the dependent variables.}$$

(Equation 3.10)

The LRI lies between zero and one. A value of zero implies a complete lack of fit while that of one indicates a perfect fit.
CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter discusses the findings obtained from the analysis of data collected through the formal farm-household survey and the informal interviews with farmers’ groups. A description of the farm households that were sampled during the farm household survey is first given in section 4.2. This is followed by an evaluation of the effectiveness of various dissemination methods in reaching farmers to inform them about calliandra technology in section 4.3. Section 4.3.3 gives an account of farmers’ awareness about the existence of the fodder tree technology and the recommended practices for its appropriate utilisation. Finally, results of the analysis of the factors influencing the probability and intensity of adoption of the fodder tree technology are discussed in section 4.4.

4.2 Characteristics of farm Households

Farm household characteristics could have implications on access to extension and adoption. The important factors that could influence access to extension information about calliandra and also the adoption of the fodder trees include gender of farmer, education, factor endowment such as land and labour, the importance, size and level of commercialisation of the dairy activity.
Gender of farmer

As mentioned in section 3.1, male and female farmers were distinguished at two levels, first, according to the gender of the household head and then on the basis of the farm manager. Household categorization by gender of the household head showed that in Embu District, majority of the dairy farm households (91 percent) were male headed (appendix iii a). This distribution was nearly the same in both Manyatta and Runyenjes divisions (about 90 percent male-headed households and 10 percent female-headed households) (appendix iii b, and c). The proportion of FHH in this survey was smaller than that of 17 and 16 percent obtained by Kimenye (1998) in Mbeere and Embu Districts respectively. The small proportion of FHH in this study could have resulted from the non-inclusion of households that were not keeping dairy animals. Compared with Kimenye’s findings, the results of this study suggest that many female-headed households did not keep dairy animals.

In the categorisation of farm households by gender of the farm manager, it was found that in majority of cases (60 percent) both husband and wife were joint managers. Twenty two percent of the farm households were female managed and 19 percent male managed. The proportions of farm households by gender of dairy activity manager were fairly similar in the two divisions. In total, most of the female-managed farm households (65 percent) were de facto female-managed. Again the proportion of FMF obtained in this study was smaller than that of 51 and 35 percent in Mbeere and Embu Districts
respectively reported by Kimenye (1998). Most farmers in FMF were probably not engaged in dairy production.

**Farm size and enterprise mix**

The average size of farms was small for the overall sample (2.7 acres\(^8\)), but it was larger in Runyenjes (3.0 acres) than in Manyatta (2.3 acres) and the difference was significant at the 1 percent level (appendix iii a, b, and c). Farms in Runyenjes especially in the lower part of the Division were however much drier. Farms tended to be larger in male-headed households than in female-headed ones. This supports findings in other studies such as Saito and Weidermann (1990) and Saito *et al* (1994). On average, MHH had 2.7 acres of land in comparison to 2.2 acres in FHH. The difference was significant at 10 percent level. Average sizes of farms were not significantly different in categories of farm households by gender of the manager.

Enterprise mix exhibited a high degree of diversity among the sampled households. This reflected the extent of farmers' efforts to minimise risks and utilise the complementarity that exists between enterprises. Cash crops (coffee and tea), food crops (maize, beans, Irish potatoes, sweat potatoes, bananas etc.), small-scale horticulture and animal production comprised the major agricultural activities. In all household categories, the largest proportion of land was devoted to food crop production followed by cash crop production. Fodder crop production was accorded the smallest proportion of land. It could

\(^8\) 1 acre=0.405 hectares
be anticipated that due to the small land holdings and competition among the different enterprises, farmers would have a preference for technologies that intensified land-use such as calliandra and would, therefore, adopt them.

**Labour**

Family labour was the chief source of farm labour in all the gender categories of households. The average number of family farm workers was higher in male than female-headed households (3.5 and 2.8 family farm workers, respectively (appendix iii a)) and the difference was significant at the 10 percent level. This tendency of farm households headed by men to be more endowed with family labour than those headed by women was observed in the two divisions (appendix iii b, and c) and is attributable to the absence of husbands in the latter category of households. The finding is consistent with the observation by Saito et al (1994) that female-headed households have less potential for family farm labour supply because of their smaller size. For household categories by gender of the dairy enterprise manager, the differences in average number of family workers showed no significant difference.

**Education**

A lower level of education was observed among women compared to men. In Manyatta Division, male heads of households had a mean of 7 years of formal education while their female counterparts had a mean of 2 years (appendix iii
b). The pattern was similar in Runyenjes Division where male and female heads of households had a mean of 6 and 4 years of formal education, respectively (appendix iii c). The difference in the average number of years of formal education among men and women heads of households was significant at the 5 percent level in Manyatta and the 10 percent level in Runyenjes.

As indicated earlier, education enhances farmers' access to information about new technologies. Better-educated farmers are also in a better position to perceive the potential benefits of adopting new innovations. It can therefore be concluded that with regard to education, farm households headed by women were at a disadvantage both in terms of accessing information about calliandra and evaluating the usefulness of the technology for the purpose of deciding whether or not to adopt.

**Features of the Dairy production activity**

Dairy production was ranked by the largest proportion of farmers (30 percent) as their third most important enterprise. On average, a household had one dairy cow and this was the case in the two divisions across all gender categories of households. Majority of farmers (over 90 percent) in all gender categories of households had improved dairy cows (exotic dairy breeds or crosses of local and the exotic breeds). Twenty one percent of the farmers (86 percent of them from Manyatta and 14 percent from Runyenjes) kept some dairy goats.
About 70 percent of the households in both divisions reported that they usually lacked enough fodder for their animals. Only about 50 percent of farmers were using dairy meal feed. Majority of farmers who were not using dairy meal (67 percent in Manyatta and 71 percent in Runyenjes) attributed this to lack of cash to purchase the feed. More farmers in Manyatta (61 percent) than Runyenjes (36 percent) were using the concentrate feed. The difference in the level of adoption of concentrate feeds in Manyatta and Runyenjes divisions could be due to differences in climatic conditions. Manyatta division is much wetter and dairy production systems are more intensive. Consequently, farmers in Manyatta were more likely to use purchased inputs including the concentrates. In addition, some farmers in Runyenjes explained that they failed to use the commercial feeds because they lacked market for the additional milk that they could realise. The problem of milk marketing in Embu District has been occasioned by the collapse of the Kenya Co-operative Creameries (KCC) and is more prevalent in Runyenjes than Manyatta because the latter is closer to Embu town (headquarters of Eastern province) where there is a high demand for milk.

Almost similar proportions of male and female-headed households were using dairy meal (48 and 50 percent respectively) and the pattern was the same in the two divisions. The proportions of households that were using dairy meal only varied slightly in household categories by gender of the farm manager. Specifically, 51 percent of farmers in JMF, 43 percent in FMF and 45 percent
in MMF were using the feeds. A similar finding on utilisation of agricultural inputs has been reported by Hassan and Salasya (1998) who found that in Kenya improved maize seeds and fertilizer technologies had been adopted by almost similar rates of men and women farmers.

In Embu District, results from this study showed that productivity of dairy animals was very low. The mean milk production per milking cow per day was only 6.0 litres (appendix iii a). This average is almost equal to that of 5.8 litres per milking cow per day reported by Omore et al (1996) in Kiambu district. Drawing from evidence from National Dairy Development Project (NDDP) farms and the better performing herds in their sample, Omore et al (1996) observed that under good feeding conditions, milk yields of 12 – 15 litres per milking cow per day are possible. The average milk production per milking cow per day was higher in Manyatta (6.0 litres) than in Runyenjes (5.4 litres) (appendix iii b and c) possibly because of more intensive production systems and widespread use of inputs like concentrate feeds in the former division. Mean milk yields were also higher in MHH (6.0 litres) than FHH (5.0 litres) possibly because of relatively better endowment of resources for farmers in the former category of households. No major differences in mean milk yields were observed within the farm household categories by gender of the manager.

The mean of the index of commercialisation of the dairy enterprise was only 0.33, implying that farmers sold just 33 percent of their total milk production.
The low proportion of the marketed milk was probably due to the low level of productivity and the problem of marketing surplus milk by some farmers. The mean in FHH (0.46) was significantly higher than that in MHH (0.32). FHH are said to be poorer than MHH (Saito et al., 1994). It is likely that the preference for cash from milk sales was higher in female than in male-headed farm households. Only small differences were observed in the average of the index of commercialisation of dairy enterprise in household categories by gender of the farm manager.

These results on farm household characteristics in Embu District confirmed the disadvantaged position of women farmers in terms of endowment of agricultural production resources as has been reported in other studies such as Saito and Weidermann (1990), Saito et al (1994) and Feldstein et al (1990). The differences in resource endowment and dairy productivity were more pronounced in household categories by gender of household head than by gender of the farm manager.

The results of the characteristics of dairy production authenticated the earlier mentioned acute problem of inadequate fodder availability and the fact that dairy farmers in the District realised milk yields far below the potential. Given the small sizes of farms and the competition between farm enterprises, adoption of technologies that can facilitate intensification in fodder production, for example, the improved fodder trees, offers the best opportunity in improving the situation.
4.3 Effectiveness of Dissemination Methods

Of the conventional dissemination methods considered, only field days and demonstrations were found to be fairly effective with most of farmers learning about the calliandra fodder tree technology through the informal method of farmer-to-farmer dissemination.

4.3.1 Conventional methods

(a) Extension farm visits

Extension farm visits involve visits by the extension staff to farmers in their farms to teach them improved farming methods. Table 2 shows the proportion of different gender categories of farm households that had been visited by the extension agents to advice farmers on calliandra and also the frequency of the visits in households that had been visited. Only 9 percent of farmers (12 percent in Manyatta and 6 percent in Runyenjes (appendix iv) had received visits and in the majority of cases where farmers had been visited (74 percent), the visits had been a one-occasion affair. These results speak very poorly of the effectiveness of the extension farm visits in reaching farmers to inform them about the fodder trees. Farmers pointed out that extension agents rarely visited them to teach them improved farming methods and when they did, they rarely talked about calliandra. Some informal discussions with front-line extension staff showed that some officers were not aware about the technology and were therefore not in a position to inform farmers about the
fewer women farmers than men had received at least an extension visit where messages on calliandra were delivered. Specifically, only 4 percent of the FHH (all from Manyatta) had at least been visited to be advised on the technology compared to 10 percent of the MHH. 

When farms were categorised by the gender of the manager, it was found that about 10 percent of JMF and MMF had received at least a visit compared to only 5 percent of the FMF. These results concur with the findings by Kimenye (1998) and Hassan and Salasya (1998) that delivery of extension information via extension farm visits tends to be biased against women. Saito and Weidermann (1990) has attributed the problem to cultural barriers, which hinder the mainly male extension agents in Africa from interacting and working with women farmers.

**Table 2: Extension farm visits on calliandra in different gender categories of households in Embu District**

<table>
<thead>
<tr>
<th>Proportion of households that had been visited (%)</th>
<th>Frequency of visits</th>
<th>Total number of households</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Never (count)</td>
<td>Once (count)</td>
</tr>
<tr>
<td>ALL FARM HOUSEHOLDS</td>
<td>9</td>
<td>273</td>
</tr>
<tr>
<td>Male-headed households (MHH)</td>
<td>10</td>
<td>246</td>
</tr>
<tr>
<td>MMF</td>
<td>10</td>
<td>53</td>
</tr>
<tr>
<td>FMF (De facto)</td>
<td>6</td>
<td>33</td>
</tr>
<tr>
<td>JMF</td>
<td>10</td>
<td>161</td>
</tr>
<tr>
<td>Female-headed households (FHH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMF (De-jure)</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>ALL FMF(De facto + De-jure)</td>
<td>5</td>
<td>59</td>
</tr>
</tbody>
</table>

Legend: MMF= Male managed farms, FMF= Female managed farms, JMF= Jointly managed farms

**Source:** Author’s survey

Fewer women farmers than men had received at least an extension visit where messages on calliandra were delivered. Specifically, only 4 percent of the FHH (all from Manyatta) had at least been visited to be advised on the technology compared to 10 percent of the MHH. When farms were categorised by the gender of the manager, it was found that about 10 percent of JMF and MMF had received at least a visit compared to only 5 percent of the FMF. These results concur with the findings by Kimenye (1998) and Hassan and Salasya (1998) that delivery of extension information via extension farm visits tends to be biased against women. Saito and Weidermann (1990) has attributed the problem to cultural barriers, which hinder the mainly male extension agents in Africa from interacting and working with women farmers.
This study also sought to determine the genders of the recipients of information about calliandra in farm households that had been visited by the extension staff to deliver the messages on the fodder tree technology. Results showed that even in households where wives jointly managed the farming activities with their husbands, in most cases the extension staff had delivered the information to men alone (Appendix v). Apparently, the extension agents did not appreciate the management role of women in the jointly managed farms. The finding in this study concur with that reported by Saito and Weidermann (1990) that in Malawi extension information was frequently delivered by the extension agents to men with the assumption that it would trickle down to women.

(b) Field days and demonstrations

Successful dissemination of improved agricultural technologies through agricultural field days and demonstrations depends on farmers' attendance to these functions. Only limited success had been realised in the dissemination of information about calliandra via agricultural field days and demonstrations because only a small proportion of farmers (19 percent) had attended these functions where messages on the fodder trees were disseminated. A higher proportion of farmers in MHH (20 percent) than in FHH (8 percent) had attended the functions and the pattern was the same in the two divisions (appendix VI). In the categories of farm households by gender of the dairy activity manager, only 14 percent of farmers in FMF had attended the field
days and demonstrations compared to 24 percent in JMF and 18 percent in MMF. In addition, in all the FMF households where farmers had attended the events, they had done so only once (Table 3). A higher proportion of farmers in *de jure* FMF (8 percent) than *de facto* FMF (3 percent) had attended the functions and the trend was the same in the two divisions.

**Table 3:** Frequency of farmers' attendance to field days and demonstrations about calliandra in Embu District

<table>
<thead>
<tr>
<th>Frequency of attendance (percentage)</th>
<th>Zero</th>
<th>Once</th>
<th>Twice</th>
<th>Three times</th>
<th>Four times</th>
<th>Five or more times</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ALL FARM HOUSEHOLDS</strong></td>
<td>81</td>
<td>14</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Male headed households (MHH)</td>
<td>80</td>
<td>14</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>MMF</td>
<td>83</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>JMF</td>
<td>76</td>
<td>17</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>FMF (De facto)</td>
<td>97</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Female-headed households (FHH)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMF (De jure)</td>
<td>92</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>All FMF (De facto + De jure)</td>
<td>86</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Legend: MMF= Male managed farms, FMF= Female managed farms, JMF= Jointly managed farms

**Source:** Author’s survey

To determine the factors that hindered farmers’ from attending agricultural field days and demonstrations, farm household managers who had never attended the functions were asked to give the most important reason that militated against their attendance. The reasons given included lack of awareness of time and place where the events were held, lack of time to attend the events, events being held very far away from homes, lack of transport, and other reasons (lack of interest, lack of invitation and sicknesses).
The importance of constraints to attendance of field days and demonstrations varied for both male and female managers of farm households. In the largest proportion of cases in MMF (16 percent), farm household managers who had never attended the functions indicated that they had failed to do so because of lack of awareness of the time and places where the events were held. In comparison, lack of time to attend the events was the most frequently cited reason by the female managers (25 percent) who had never attended the functions. Nevertheless, lack of awareness of time and place where the events were held was also an important constraint to attendance in FMF. The constraint was cited by a total of 24 percent of the female farm managers who had never attended the event.

In JMF, the importance of the main constraints to attendance to field days and demonstrations by men and by women also varied. In most of the cases in the household category (46 percent), men who had not attended the events said that they failed to do so mainly because of the lack of interest, lack of invitation, and sicknesses. In comparison, the largest proportion of women (24 percent) cited lack of time due to their other productive and reproductive roles.

(c) On-farm trials

On-farm trials involve collaborative work between researchers and farmers to evaluate new technologies under the farmers’ conditions. The on-farm research work is valued because it provides a way through which farmers’
interests can be incorporated in the development of new technologies and thus enhances adoption. There is an increasing shift in agricultural research to on-farm work. For on-farm research to be effective in disseminating new technologies to women farmers, the women farmers must be chosen to participate in the work. In Embu District, on-farm trials comprised the initial stage of calliandra fodder tree technology dissemination. During the trials, participant farmers were provided with free calliandra planting material and also the necessary information on management and utilisation of the fodder trees.

Only about 3 percent of the sampled farm households had participated in the on-farm trials on calliandra (Table 4). The ineffectiveness of on-farm trials in disseminating calliandra technology to large numbers of farmers was perhaps due to little on-farm work that has been done on calliandra. In addition, lack of adequate resources by research and extension naturally limits participation in on-farm trials to only a few farmers. According to Franzel et al (1996) only a total of 64 farmers in the whole district had participated in the on-farm trials on calliandra by NARP by 1993.

Six of the sample farmers in Manyatta had participated in the trials compared to only two in Runyenjes. None of the farmers in FHH had taken part in the trials compared to 8 in MHH. In spite of its inability to disseminate information about calliandra to many farmers, on-farm trials were very effective in educating participant farmers about the technology. In this regard,
farmers who had participated in the trials tended to be very informed about various recommendations about the technology utilisation.

Table 4: Numbers of farmers' that had participated in on-farm calliandra trials in different gender categories of farm households in Embu District

<table>
<thead>
<tr>
<th></th>
<th>Embu District</th>
<th>Manyatta Division</th>
<th>Runyenjes Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>All households</td>
<td>8</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Male-headed households (MHH)</td>
<td>8</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>MMF</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>JMF</td>
<td>6</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>FMF (De facto)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Female-headed households (FHH)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMF (De jure)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>FMF (De facto + De jure)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Numbers in parenthesis are percentages of households, which took part in the on-farm trials in the respective gender categories of households with reference to the total sample size.

Legend: MMF= Male managed farms, FMF= Female managed farms, JMF= Jointly managed farms

Source: Author's survey

4.3.2 Informal methods

(a) Farmers' groups

Use of groups in agricultural extension has increasingly gained prominence (Garforth, 1982) and this is attributable to a number of factors. The factors include the inability of other diffusion methods to promote widespread equitable development and the fact that the group approach is economical, it facilitates adoption, and is a focus for community action.

Only a small proportion of farm households (9 percent) had been reached in
the dissemination of information about calliandra through groups. The proportions of households reached through groups in the various gender-categories of farm households were not significantly different. Nevertheless, FMF had the lowest proportion of households, which were reached through groups, that is, 5 percent, in comparison to 10 and 7 percent of the joint and male managed farms, respectively. When the gender of the specific persons reached through groups was considered, it was found that more women (17) had received some extension information about calliandra through groups compared to only 9 men. The women who had been reached represented 7 percent of farmers in FMF and JMF as compared to only 3 percent in MMF. About 7 and 6 percent of women in *de jure* and *de facto* female managed farms respectively had accessed information about calliandra through groups.

In some interviews with groups that had been used in calliandra dissemination it was found that all the groups’ members had heard about calliandra and most of them knew how to produce calliandra seedlings. Awareness of the correct practices of maintaining and utilising calliandra trees once transplanted in the farm was, however, lacking for most members. This included lack of awareness of the correct cutting height, proper cutting implement, feeding calliandra prunings soon after cutting and the recommended number of trees in the production of own seeds. Unlike the production of seedlings which the group members learnt as they worked with extension officers, most of the practices in maintenance and utilisation of the calliandra trees had been
theoretically taught to the members and the majority had forgotten them.

Out of the six groups that were interviewed, only one had made some arrangements on multiplication of calliandra seeds. Initially, all the groups had obtained their planting material (seeds) through donations by KARI and NARP. They were all advised to leave out some of their calliandra trees to produce seeds, which they would have then used to produce more seedlings either for sale or for sharing among the members. At the time of the interviews, 4 of the 6 groups did not have any calliandra seedlings in their nurseries. Three of the groups blamed this on lack of seeds. They hoped for a donation of more seeds. One women group in Runyenjes had all its seedlings stolen while still in the nursery.

(b) Farmer to farmer dissemination

Informal farmer-to-farmer dissemination was by far the most significant method of disseminating calliandra fodder tree technology. The largest proportion of farmers (50 percent) who were aware about the fodder trees first got the information from other farmers and the trend was the same across all the gender categories of farm households. After first becoming aware of the calliandra technology, a considerable fraction of farmers (31 percent) visited other farmers who had adopted the fodder trees in search for more information about the technology. Farmer to farmer exchange also played a vital role as a source of calliandra planting material for farmers. About 30 percent of farmers with calliandra indicated that they obtained their initial
planting material from other farmers. In essence, the farmer-to-farmer exchange was the most frequently cited source of the planting material after extension. The important role of farmer-to-farmer dissemination of agricultural technologies has also been observed by Irungu (119) who found that in Kiambu District, this mode of dissemination played an important role in the spread of napier grass technology.

One constraint to more effective diffusion of calliandra through the informal farmer to farmer mode of technology dissemination was that in some cases, calliandra adopter farmers felt that other farmers wasted their time when they visited them to enquire about the fodder trees. In addition, some of the very poor farmers did not like visiting some calliandra adopter farmers because of the difference in social status.

4.3.3 Farmers' level of awareness of calliandra fodder tree technology and proper utilisation

A possible indicator of the overall effectiveness of the dissemination methods that had been used in calliandra diffusion could be farmers' awareness of the existence of the fodder tree technology and aspects of its utilisation. Sixty six percent of farmers were aware of the fodder tree technology implying that 34 percent were still unaware. More farmers in Manyatta (79 percent) had heard about calliandra than in Runyenjes division (52 percent). The higher level of awareness about the existence of the technology in Manyatta than in Runyenjes could be attributed to the fact that the methods that had been used
in the dissemination had managed to reach more farmers in the former division than in latter.

A bias against women farmers was apparent in the overall effectiveness of the dissemination methods. Specifically, a higher proportion of farmers in MHH (66 percent) than FHH (57 percent) was aware of calliandra. For farm types by gender of the manager, JMF had the highest proportion of households where farmers had heard about the technology i.e. 92 percent, followed by MMF (61 percent) and FMF (45 percent). The trend was the same in the two divisions but the respective percentages in the three types of households in Runyenjes were lower than in Manyatta. The low level of awareness about the existence of the technology among the women farmers could be attributed to the observed bias against women by most of the methods that had been used in the dissemination of information about the technology.

For proper utilization of calliandra fodder trees, scientists recommend that pruning be done at a height of 1 meter or below using pruning shears and the prunings be fed to the livestock not more than one hour after cutting. Most farmers with calliandra (71 percent) were unaware of the time duration within which the prunings should be fed to the animals and about half did not know the appropriate cutting height and implement. Besides awareness of the utilisation recommendations, cultural and gender factors also influenced the implementation of some of the recommendations by farmers. For example, despite most calliandra farmers in FMF (88 percent) being aware that pruning
shears was the right implement for harvesting calliandra prunings, a high proportion of them (68 percent) were not using the shears. Use of the pruning shears was, however, more common in male and jointly managed farms. In FMF, women were the ones who were mainly involved in cutting and feeding calliandra to the animals. In the community, pruning shears are predominantly a man's tool (personal communication). Most women tended to use the panga when harvesting the calliandra prunings. In addition, most of the women complained that they were constrained by time and that use of pruning shears was too time consuming. Most of them were however unaware that use of pangas and breaking off of branches was a major cause of mortality of the fodder trees. In one household, a farmer who was breaking off branches from her calliandra trees had all of them die when they were already mature.

4.3.4 Adoption of Calliandra and other types of fodder trees

Both descriptive statistics and tobit regression were used to analyse adoption. From the descriptive statistics it was found that the rate of adoption of the fodder trees was rather low. Only 49, (16 percent) of the sampled households had calliandra (Table 5). The number of trees in households that had adopted the fodder was also low. On average, an adopter household had 89 trees which, according to Franzel et al (1996) is only 18 percent of the number of trees required for a farmer to completely substitute calliandra for dairy meal per dairy animal unit. A higher proportion of farmers in Manyatta (21 percent) than in Runyenjes (11 percent) had calliandra but the average
number of trees per adopter household was almost the same in the two divisions.

More farmers in MHH (17 percent) than FHH (11 percent) had taken up calliandra and the trend was the same in the two divisions. In the three categories of farm households by gender of the farming activity manager, almost equal proportions of farmers had calliandra but farmers in JMF tended to have more trees than their counterparts in male and female managed farms. Specifically, adopter farmers in JMF had an average of 120 trees compared to only 35 and 40 trees in male and female managed farms, respectively.

In addition to calliandra, farmers in Embu District also grew leucaena and mulberry trees for fodder. Leucaena was the second most prevalent fodder tree after calliandra in the district but only a small proportion of farmers (14 percent) grew it. Leucaena was, however, the most common fodder tree in Runyenjes division where 21 percent of farmers grew it. In this division leucaena was most common in the lower drier parts although a few farmers in the upper wetter parts of the division grew it. A major constraint to widespread adoption of leucaena was its susceptibility to attack by aphids (*Heteropsyla Cubana*), which reduced the amount of forage produced. In addition, the aphids attack made leucaena produce some bad smell and therefore farmers did not like planting it near dwelling places. Most farmers who had leucaena fed it to goats only. Apparently, they were not aware that it was also a good feed for dairy cows.
Only a handful of farmers (6 percent) had mulberry and most of them were in Runyenjes division. Mulberry was rarely fed to livestock even among farmers who had it perhaps because they did not know that it was a good feed for the animals. It was only in one household in Manyatta where the tree had primarily been planted for fodder. Another fodder tree that scientists have tried to promote in regions including the study area is sesbania. However, only one of the sampled households grew it for fodder.
Table 5: Calliandra fodder tree adoption in Embu District

<table>
<thead>
<tr>
<th></th>
<th>Embu District</th>
<th></th>
<th></th>
<th>Manyatta division</th>
<th></th>
<th></th>
<th></th>
<th>Runyenjes division</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>% of farms with calliandra</td>
<td>Average No. of calliandra trees</td>
<td>N</td>
<td>% of farms with calliandra</td>
<td>Average No. of calliandra trees</td>
<td>N</td>
<td>% of farms with calliandra</td>
<td>Average No. of calliandra trees</td>
<td></td>
</tr>
<tr>
<td>All farm households</td>
<td>300</td>
<td>16</td>
<td>89</td>
<td>150</td>
<td>21</td>
<td>89</td>
<td>150</td>
<td>11</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>Male-headed households (MHH)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMF</td>
<td>59</td>
<td>18</td>
<td>35</td>
<td>28</td>
<td>18</td>
<td>40</td>
<td>31</td>
<td>17</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>JMF</td>
<td>179</td>
<td>17</td>
<td>120</td>
<td>94</td>
<td>22</td>
<td>116</td>
<td>85</td>
<td>9</td>
<td>132</td>
<td></td>
</tr>
<tr>
<td>FMF (de facto)</td>
<td>34</td>
<td>16</td>
<td>20</td>
<td>13</td>
<td>23</td>
<td>17.3</td>
<td>21</td>
<td>13</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Female-headed households (FHH)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMF (de jure)</td>
<td>28</td>
<td>11</td>
<td>89</td>
<td>15</td>
<td>13</td>
<td>93</td>
<td>13</td>
<td>8</td>
<td>80.1</td>
<td></td>
</tr>
<tr>
<td>FMF (de facto + de jure)</td>
<td>62</td>
<td>16</td>
<td>40</td>
<td>28</td>
<td>23</td>
<td>45</td>
<td>34</td>
<td>13</td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>

Legend: MMF= Male managed farms, FMF= Female managed farms, JMF= Jointly managed farms

Source: Author’s survey
4.4 Econometric analysis of determinants of calliandra adoption

This section presents the results of the Tobit analysis of the determinants of calliandra adoption among all farmers in general and also the different gender categories of farm households in Embu District. As mentioned in section 3.5.1 and 3.5.2, data used for the Tobit analyses was screened for the econometric problems of multicollinearity and heteroscedasticity. Farmers’ perception about the effect of calliandra on milk butter fat content (CALMQ) was highly correlated with the perceived effect of the fodder trees on milk production (CALMP) (0.83) (appendix i) and was therefore dropped as an explanatory variable. The hypothesis that the data was heteroscedastic was rejected in all cases that the Tobit model was estimated (appendix ii). It was not possible to compare the factors influencing adoption in male and female-headed households because of inadequate cases of adopter farmers in the female-headed households. Subsequently, the hypothesis that similar factors affect the adoption of the fodder trees in alternate gender categories of farm households was only evaluated for the classes of households by gender of the dairy enterprise manager.

4.4.1 Determinants of probability and intensity of adoption of calliandra fodder trees in Embu District

Table 6 shows the Tobit maximum likelihood estimates and marginal effects of factors influencing the adoption of calliandra in Embu District. The model
had an explanatory power of 0.16 implying that the included independent variables accounted for 16 percent of the total variation in the dependent variable. This explanatory power compares well with that of 0.13 obtained by Nkonya et al (1997) in their study of the factors affecting the adoption of improved maize seeds in Tanzania.

Factors that significantly influenced adoption included education, degree of commercialisation of the dairy enterprise, farmers’ perception that calliandra could enhance productivity, access to extension information about calliandra and participation in calliandra on-farm trials.

**Table 6**: Tobit maximum likelihood estimates and marginal effects of factors influencing adoption of calliandra fodder trees in Embu District

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. error</th>
<th>Total change in adoption</th>
<th>Change in adoption intensity (trees)</th>
<th>Change in adoption probability (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-34.79***</td>
<td>11.99</td>
<td>-3.2</td>
<td>-0.76</td>
<td>-24</td>
</tr>
<tr>
<td>Age of household head (years)</td>
<td>-0.018</td>
<td>0.12</td>
<td>-0.0016</td>
<td>-0.00039</td>
<td>-0.012</td>
</tr>
<tr>
<td>Education of household head (years)</td>
<td>1.19**</td>
<td>0.53</td>
<td>0.11</td>
<td>0.026</td>
<td>0.83</td>
</tr>
<tr>
<td>Size of farm (Acres)</td>
<td>-0.27</td>
<td>0.75</td>
<td>-0.024</td>
<td>-0.0059</td>
<td>-0.19</td>
</tr>
<tr>
<td>Number of family farm workers</td>
<td>0.81</td>
<td>0.70</td>
<td>0.074</td>
<td>0.018</td>
<td>0.56</td>
</tr>
<tr>
<td>Index of commercialisation of dairy</td>
<td>9.99*</td>
<td>5.20</td>
<td>0.91</td>
<td>0.22</td>
<td>6.92</td>
</tr>
<tr>
<td>Effect of calliandra on productivity (0,1)</td>
<td>15.49***</td>
<td>4.25</td>
<td>1.41</td>
<td>0.34</td>
<td>10.74</td>
</tr>
<tr>
<td>Extension on calliandra (0,1)</td>
<td>8.10**</td>
<td>3.42</td>
<td>0.74</td>
<td>0.18</td>
<td>5.62</td>
</tr>
<tr>
<td>Participation in on-farm calliandra trials (0,1)</td>
<td>21.80***</td>
<td>5.91</td>
<td>1.99</td>
<td>0.48</td>
<td>15.10</td>
</tr>
<tr>
<td>Membership to calliandra group (0,1)</td>
<td>3.10</td>
<td>7.80</td>
<td>0.28</td>
<td>0.68</td>
<td>2.15</td>
</tr>
<tr>
<td>Division (1=Manyatta, 0=otherwise)</td>
<td>-3.21</td>
<td>3.27</td>
<td>-0.29</td>
<td>-0.070</td>
<td>-0.022</td>
</tr>
<tr>
<td>Gender of household head (1=Male0=otherwise)</td>
<td>-4.01</td>
<td>6.47</td>
<td>-0.36</td>
<td>-0.088</td>
<td>-0.028</td>
</tr>
</tbody>
</table>
| Restricted Log likelihood function = -295.82 | z= 0.99 | F(z)= 0.16 | f(z)=0.99
| Log likelihood function =-250.87      |             |             |                          |                                      |
| Likelihood ratio index = 0.16         |             |             |                          |                                      |
| Model size = 150 observations         |             |             |                          |                                      |

***, ** and * = Significant at 1, 5 and 10 percent level respectively

**Source**: Author’s survey
Perception that calliandra could enhance productivity had the expected positive sign and was significant at 1 percent level. This concurs with findings by Adesina and Zinnah (1992), Adesina and Seidi (1995), Adesina and Forson (1995) and Kimenye (1998) that farmers’ perceptions of attributes of technologies have significant effects on adoption decisions. It shows that smallholder dairy farmers, as entrepreneurs are willing to take up innovations whenever they judge them as being beneficial. Benefits from the productivity-increasing attribute of calliandra arise from the fact that with higher milk output farmers have more milk to consume and to sell for extra income.

Participation in on-farm trials on calliandra had the anticipated positive sign and was significant in influencing the probability and intensity of adoption at 1 percent level. This result concurs with the finding by Adesina and Forson (1995) who reported that participation in on-farm tests significantly influenced the adoption of modern sorghum varieties in Burkina Faso. Participation in on-farm trials gives farmers exposure to the technologies being tried in their farms. Farmers who had participated in the on-farm trials on calliandra were most likely to adopt the fodder trees because they were in a much better position of learning the benefits derivable from the technology. Participation in the on-farm trials also provided farmers incentives to adopt such as free planting material. In addition, trial participant farmers get the opportunity to have their views considered during this latter stage of technology development (Kimenye, 2001) so that the final technology packages are more suited to their
needs and circumstances and hence more adoptable by them.

Education had the expected positive sign and was significant in influencing the probability and intensity of adoption at 5 percent level. As earlier pointed out, education enhances farmers' access to information about new technologies. Educated farmers were also likely to be less risk averse as they were in a better position to perceive the benefits of adopting the fodder tree technology. A positive and significant relationship between farmers' level of formal education and technology adoption has also been reported by Ha et al (1991) in their analysis of the use of improved agriculture technology in eastern province of Zambia.

As expected, access to extension had a positive and significant (5 percent level) impact on the probability and intensity of adoption. This underscores the importance of extension services in informing farmers about improved technologies. A similar finding has been reported by Harper et al (90) in their investigation of the factors affecting the adoption of insect swp nets and insecticides to control the rice stink bug by Texas rice farmers. It can therefore be expected that calliandra adoption could be enhanced if the extension campaign on the fodder trees was strengthened so that many farmers were reached.

Degree of commercialisation of the dairy enterprise was also positively related to the probability and intensity of adoption and was significant at 10 percent level. During the farm household survey some farmers indicated that they
were experiencing a problem of lack of market for their milk, a situation that had resulted from the collapse of the Kenya Co-operative Creameries (KCC). It can be argued that for a given household, the higher the amount of milk that it managed to sell, the higher the potential monetary gains from calliandra adoption and thus the higher the incentive of adopting the fodder trees. A farmer who was aware about calliandra but had not adopted explained that he saw no need of planting the fodder trees because there was nowhere to sell the extra milk that would be produced by adopting the fodder trees. This shows that poor marketing systems discourage farmers from adopting improved technologies. There is therefore a need to improve milk marketing in Embu District if farmers are going to adopt and, therefore, benefit from the improved fodder tree technology.

As discussed in section 3.2, marginal changes in adoption associated with unit changes in the values of explanatory variables were decomposed into changes in probability of adoption and changes in the intensity of adoption. Results indicated higher marginal changes in adoption probabilities than in the adoption intensities. The low marginal values of adoption intensity were perhaps because of the very low intensity of adoption that was observed. A positive change in perception that calliandra could enhance productivity increased adoption by about 1.4 trees which entailed an increase in probability of adoption of about 11 percent and an increase in adoption intensity of about 0.3 trees. Participation in on-farm trials increased adoption by about 2 trees
and this comprised of a 15 percent increase in adoption probability and an increase in adoption intensity of about 0.5 trees. Access to extension improved adoption by about 0.7 trees, which included a 6 percent increase in adoption probability and an increase in adoption intensity of about 0.2 trees. An extra year of formal education enhanced calliandra adoption by about 0.1 trees and this included an adoption probability increase of 8 percent and an increase in adoption intensity of about 0.03 trees. A one-point increase in commercialisation of the dairy enterprise enhanced adoption by 0.9 trees, which included a 7 percent increase in adoption probability and a 0.2 trees increase in adoption intensity.

4.4.2 Comparing the determinants of probability and intensity of adoption of calliandra in Manyatta and Runyenjes Divisions

To investigate whether some variation existed in the factors influencing calliandra adoption in Manyatta and Runyenjes divisions, a Tobit model was estimated for each division. Results showed that in Manyatta adoption was significantly influenced by perception that calliandra could enhance productivity, extension and participation in on-farm trials (Table 7). Specifically, perception that calliandra could enhance productivity had the expected positive sign and was significant at 1 percent level while extension and participation in on-farm trials also had the predicted positive signs and were significant at 5 percent level. From the analysis of marginal effects, a positive change in perception that calliandra could improve productivity could
enhance adoption by 0.8 trees and this entailed an increase in adoption probability of 6 percent and an increase in adoption intensity of 0.2 trees. Extension could enhance adoption by about 0.5 trees, which included increases in adoption probability and adoption intensity of 4 percent and 0.1 trees, respectively. Participation in on-farm trials could increase adoption by 0.9 trees, which entailed a 7 percent increase in adoption probability and a 0.2 trees increase in adoption intensity.

Table 7: Tobit maximum likelihood estimates and marginal effects of factors influencing adoption of calliandra fodder trees in Manyatta division

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. error</th>
<th>Total change in adoption</th>
<th>Change in adoption intensity (trees)</th>
<th>Change in adoption probability (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>37.01***</td>
<td>12.58</td>
<td>-2.00</td>
<td>-0.42</td>
<td>-15.76</td>
</tr>
<tr>
<td>Age of household head (years)</td>
<td>-0.048</td>
<td>0.15</td>
<td>-0.0026</td>
<td>-0.00055</td>
<td>-0.02</td>
</tr>
<tr>
<td>Education of household head (years)</td>
<td>0.94</td>
<td>0.58</td>
<td>0.051</td>
<td>0.011</td>
<td>0.40</td>
</tr>
<tr>
<td>Size of farm (Acres)</td>
<td>0.19</td>
<td>1.12</td>
<td>0.010</td>
<td>0.0021</td>
<td>0.079</td>
</tr>
<tr>
<td>Number of family farm workers</td>
<td>1.21</td>
<td>0.74</td>
<td>0.065</td>
<td>0.014</td>
<td>0.52</td>
</tr>
<tr>
<td>Index of commercialisation of dairy</td>
<td>2.81</td>
<td>5.98</td>
<td>0.15</td>
<td>0.032</td>
<td>1.20</td>
</tr>
<tr>
<td>Effect of calliandra on productivity (0,1)</td>
<td>14.26***</td>
<td>5.03</td>
<td>0.77</td>
<td>0.16</td>
<td>6.07</td>
</tr>
<tr>
<td>Extension on calliandra (0,1)</td>
<td>9.24**</td>
<td>4.25</td>
<td>0.50</td>
<td>0.10</td>
<td>3.94</td>
</tr>
<tr>
<td>Participation in on-farm calliandra trials (0,1)</td>
<td>17.15**</td>
<td>7.03</td>
<td>0.92</td>
<td>0.19</td>
<td>7.30</td>
</tr>
<tr>
<td>Membership to calliandra group (0,1)</td>
<td>-22.22</td>
<td>699.45</td>
<td>-1.20</td>
<td>-0.25</td>
<td>-9.46</td>
</tr>
<tr>
<td>Restricted Log likelihood function</td>
<td>-184.50</td>
<td></td>
<td>z=0.79</td>
<td>f(z)= 0.213</td>
<td>f(z)=0.2920</td>
</tr>
<tr>
<td>Log likelihood function</td>
<td>-162.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood ratio index</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model size</td>
<td>150 observations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***, ***, ** and *= Significant at 1, 5 and 10 percent level respectively

Source: Author's survey

In Runyenjes, calliandra adoption was significantly influenced by degree of commercialisation of dairy enterprise, participation in on-farm trials, perception that calliandra could improve productivity and extension (Table 8).
Specifically, degree of commercialisation of dairy enterprise and participation in on-farm trials had the anticipated positive signs and were significant at 1 percent level. Perception that calliandra could improve productivity and extension also had the hypothesized positive relationships with adoption and were significant at 5 and 10 percent levels respectively. Marginal changes in calliandra adoption in the division were too small and this was due to the very low levels of adoption that were observed in the division.

**Table 8: Tobit maximum likelihood estimates and marginal effects of factors influencing adoption of calliandra fodder trees in Runyenjes division**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. error</th>
<th>Total change in adoption</th>
<th>Change in adoption intensity (trees)</th>
<th>Change in adoption probability (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-47.84***</td>
<td>17.07</td>
<td>-0.048</td>
<td>-0.0081</td>
<td>-0.40</td>
</tr>
<tr>
<td>Age of household head (years)</td>
<td>0.14</td>
<td>0.21</td>
<td>0.0014</td>
<td>0.00004</td>
<td>0.0012</td>
</tr>
<tr>
<td>Education of household head (years)</td>
<td>0.99</td>
<td>0.84</td>
<td>0.00099</td>
<td>0.0001</td>
<td>0.0082</td>
</tr>
<tr>
<td>Size of farm (Acres)</td>
<td>-0.68</td>
<td>1.07</td>
<td>-0.0068</td>
<td>-0.0001</td>
<td>-0.0057</td>
</tr>
<tr>
<td>Number of family farm workers</td>
<td>-3.26</td>
<td>1.70</td>
<td>-0.0033</td>
<td>-0.0005</td>
<td>-0.027</td>
</tr>
<tr>
<td>Index of commercialisation of dairy</td>
<td>33.51***</td>
<td>9.88</td>
<td>0.034</td>
<td>0.0057</td>
<td>0.28</td>
</tr>
<tr>
<td>Effect of calliandra on productivity (0,1)</td>
<td>15.76**</td>
<td>6.81</td>
<td>0.016</td>
<td>0.0027</td>
<td>0.13</td>
</tr>
<tr>
<td>Extension on calliandra (0,1)</td>
<td>9.58*</td>
<td>5.17</td>
<td>0.0096</td>
<td>0.0016</td>
<td>0.079</td>
</tr>
<tr>
<td>Participation in on-farm calliandra trials (0,1)</td>
<td>36.80***</td>
<td>9.73</td>
<td>0.037</td>
<td>0.0063</td>
<td>0.31</td>
</tr>
<tr>
<td>Membership to calliandra group (0,1)</td>
<td>-1.97</td>
<td>7.10</td>
<td>-0.0020</td>
<td>-0.0003</td>
<td>-0.016</td>
</tr>
<tr>
<td>Restricted Log likelihood function =-108.80</td>
<td>z= 1.21</td>
<td>F(z)= 0.113</td>
<td>f(z)=0.1919</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***, ** and * = Significant at 1, 5 and 10 percent level respectively

**Source:** Author’s survey

The results for the determinants of adoption for each division reflect what was basically found for the whole sample (Embu). The perception that calliandra could improve productivity, extension, and participation in on-farm trials, positively and significantly influenced adoption in the whole district and also
in each of the two divisions. However, although the index of commercialisation of dairy enterprise was significant in the model for the whole district, in the models for the two separate divisions, it was only significant in Runyenjes. This result can be interpreted in the light of the milk-marketing problem, which was most prevalent in Runyenjes. Thus, unlike in Manyatta where most farmers could sell their milk with ease, in the Runyenjes Division, the ability to sell milk played a significant decisive role in determining adoption. It is therefore important to address the problem of the marketing of milk in order to provide an incentive for farmers in Runyenjes division to adopt and benefit from the calliandra fodder tree technology.

4.4.3 Determinants of probability and intensity of calliandra adoption in different categories of dairy farms by gender of the manager

4.4.3.1 Factors influencing adoption of calliandra in male managed farms (MMF)

The results of the Tobit analysis in MMF were generally consistent with the apriori expectations about the influence of various factors on adoption of improved farming technologies. Factors that significantly influenced calliandra adoption in MMF included age, education, family labour, perception that calliandra could improve productivity, extension and participation in on-farm trials (Table 9). Age had the hypothesized negative
sign and was significant at 1 percent level. As earlier mentioned, literature on adoption suggests that older farmers may lack interest in new technology. There is overwhelming evidence that older people, unless highly educated, are generally not quick at taking up new things. They tend to fall under the “late majority” in the adoption / diffusion curve.

Educations, family labour, perception that calliandra could improve productivity and participation in on-farm trials were positively related to adoption and were significant at 1 percent level. Educated farmers tend to be more aware of new things and are able to perceive the benefits of adopting innovations. For family labour, labour may have been constraining in most MMF because of the high land-labour ratios that were observed in these households. On average, MMF households had a land-labour ratio of 0.94 compared to 0.80 and 0.72 for female and jointly managed farm households respectively. Adoption of calliandra introduces additional labour inputs requirement for such regular activities like pruning. Consequently, male managed farms with more family labour might have found it easy to adopt the fodder trees. The significantly positive influence of perception that calliandra could improve productivity on adoption confirm that in MMF the productivity increasing attribute is a welcome characteristic of the fodder tree technology. The significant coefficient on participation in on-farm trials confirms the important role that trying out of new technologies in farmers’ farm plays in the diffusion of these technologies.
Table 9: Tobit maximum likelihood estimates and marginal effects of factors influencing adoption of calliandra fodder trees in MMF in Embu District

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. error</th>
<th>Total change in adoption</th>
<th>Change in adoption intensity (trees)</th>
<th>Change in adoption probability (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-13.09***</td>
<td>4.97</td>
<td>-0.01</td>
<td>-0.003</td>
<td>-0.1</td>
</tr>
<tr>
<td>Age of household manager (years)</td>
<td>-0.18***</td>
<td>0.05</td>
<td>-0.0002</td>
<td>0.00004</td>
<td>-0.001</td>
</tr>
<tr>
<td>Education of household manager (years)</td>
<td>0.67***</td>
<td>0.25</td>
<td>0.0007</td>
<td>0.0002</td>
<td>0.005</td>
</tr>
<tr>
<td>Size of farm (Acres)</td>
<td>1.02*</td>
<td>0.42</td>
<td>0.01</td>
<td>0.0002</td>
<td>0.008</td>
</tr>
<tr>
<td>Number of family farm workers</td>
<td>1.36***</td>
<td>0.38</td>
<td>0.001</td>
<td>0.0003</td>
<td>0.01</td>
</tr>
<tr>
<td>Index of commercialisation of dairy</td>
<td>0.20</td>
<td>2.27</td>
<td>0.0002</td>
<td>0.00005</td>
<td>0.001</td>
</tr>
<tr>
<td>Effect of calliandra on productivity (0,1)</td>
<td>7.91***</td>
<td>2.11</td>
<td>0.0008</td>
<td>0.002</td>
<td>0.06</td>
</tr>
<tr>
<td>Extension on calliandra (0,1)</td>
<td>2.29*</td>
<td>1.32</td>
<td>0.002</td>
<td>0.0006</td>
<td>0.02</td>
</tr>
<tr>
<td>Participation in on-farm calliandra trials (0,1)</td>
<td>5.73***</td>
<td>1.83</td>
<td>0.006</td>
<td>0.001</td>
<td>0.04</td>
</tr>
<tr>
<td>Membership to calliandra group (0,1)</td>
<td>-3.19</td>
<td>2.12</td>
<td>-0.003</td>
<td>-0.0008</td>
<td>-0.02</td>
</tr>
<tr>
<td>Division (1=Manyatta, 0=Otherwise)</td>
<td>0.92</td>
<td>1.64</td>
<td>0.0009</td>
<td>0.0002</td>
<td>0.007</td>
</tr>
<tr>
<td>Restricted Log likelihood function =49.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood function = 19.86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood ratio index = 0.59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model size = 150 observations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***, ** and * = Significant at 1, 5 and 10 percent level respectively

Source: Author's survey

The influence of farm size and extension on calliandra adoption in MMF was also positive and significant at 10 percent level. It can be argued that farmers with large farms had space to try out calliandra and to plant many of these fodder trees once they had adopted. In addition, such farmers may have been economically better off and thus could afford to buy calliandra-planting material. It could also be that farmers were not aware that calliandra could be grown along the internal and external boundaries, along the soil conservation bands or inter-cropped with napier. As pointed out earlier, the positive significant relationship between extension and adoption confirms the importance of extension service in the diffusion of new technologies.
Marginal effects on adoption associated with changes in values of the explanatory variables in MMF were very small and this was attributable to the extremely low level of adoption that was observed. For example, participation in on farm trials could only enhance adoption by 0.006 trees, which comprised of 0.04 percent increase in adoption probability and an increase in adoption intensity of 0.001 trees. Access to extension enhanced adoption by 0.002 trees and this included an increase in adoption probability of 0.02 percent and an increase in adoption intensity of 0.001 trees. A similar observation of very small marginal changes in the probability and intensity of adoption were made for age, education, farm size and perception that calliandra can increase milk productivity.

4.4.3.2 Factors influencing calliandra adoption in female managed farms (FMF)

In FMF only perception that calliandra could improve productivity and division were significant in influencing adoption (Table 10). In particular, perception that calliandra could improve productivity had the hypothesized positive sign and was significant at 5 percent level. Division was also positively related to the probability and intensity of adoption and was significant at 5 percent level implying that in FMF the probability and intensity of adoption were significantly higher in Manyatta than in Runyenjes.
Table 10: Tobit maximum likelihood estimates and marginal effects of factors influencing adoption of calliandra fodder trees in FMF in Embu District

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. error</th>
<th>Total change in adoption</th>
<th>Change in adoption intensity</th>
<th>change in adoption probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-29.55</td>
<td>12.73</td>
<td>-0.02955</td>
<td>-0.068</td>
<td>-0.2276</td>
</tr>
<tr>
<td>Age of household manager (years)</td>
<td>0.07</td>
<td>0.13</td>
<td>0.000066</td>
<td>0.00015</td>
<td>0.00051</td>
</tr>
<tr>
<td>Education of household manager (years)</td>
<td>-0.11</td>
<td>0.44</td>
<td>-0.000011</td>
<td>-0.0002</td>
<td>-0.0008</td>
</tr>
<tr>
<td>Size of farm (Acres)</td>
<td>-0.05</td>
<td>0.81</td>
<td>-0.00005</td>
<td>-0.0001</td>
<td>-0.0004</td>
</tr>
<tr>
<td>Number of family farm workers</td>
<td>-1.67</td>
<td>1.14</td>
<td>-0.0017</td>
<td>-0.0038</td>
<td>-0.013</td>
</tr>
<tr>
<td>Index of commercialisation of dairy</td>
<td>12.56</td>
<td>8.96</td>
<td>0.013</td>
<td>0.029</td>
<td>0.097</td>
</tr>
<tr>
<td>Effect of calliandra on productivity (0,1)</td>
<td>9.95**</td>
<td>4.20</td>
<td>0.01</td>
<td>0.002</td>
<td>0.077</td>
</tr>
<tr>
<td>Extension on calliandra (0,1)</td>
<td>0.90</td>
<td>4.01</td>
<td>0.0009</td>
<td>0.0002</td>
<td>0.0069</td>
</tr>
<tr>
<td>Participation in on-farm calliandra trials (0,1)</td>
<td>13.99</td>
<td>9.49</td>
<td>0.014</td>
<td>0.0032</td>
<td>0.1077</td>
</tr>
<tr>
<td>Membership to calliandra group (0,1)</td>
<td>1.43</td>
<td>6.13</td>
<td>0.0014</td>
<td>0.00033</td>
<td>0.011</td>
</tr>
<tr>
<td>Division (1=Manyatta, 0=Otherwise)</td>
<td>9.66**</td>
<td>4.28</td>
<td>0.01</td>
<td>0.0022</td>
<td>0.074</td>
</tr>
<tr>
<td>Restricted Log likelihood function = -48.99</td>
<td>z= 0.99</td>
<td></td>
<td>F(z)= 0.16</td>
<td>f(z)=0.24</td>
<td></td>
</tr>
</tbody>
</table>

Log likelihood function = 35.91
Likelihood ratio index = 0.27
Model size = 65 observations

***, ** and * = Significant at 1, 5 and 10 percent level respectively

Source: Author's survey

Extension had no significant effect on calliandra adoption in FMF. The problem was that contact with extension for farmers who had had access to extension in FMF was not frequent. For example, unlike the case in jointly and male managed farms, all the female managed farms that had received some extension farm visits on calliandra had received only one visit each (Table 2). Attendance of field days and demonstrations among farmers who had attended the functions in FMF was also not frequent (Table 3). A one-occasion exposure to extension information may not be sufficient to influence farmers to adopt a technology. To adopt the fodder trees, FMF probably needed more access to extension service. Participation in on-farm trials was also not significant. Only 1 of the sampled FMF had participated in the on-farm trials. As a result, the variable lacked sufficient variation, and was not a factor in the regression model for FMF.
Marginal effects on adoption due to changes in values of the explanatory variables were very small again due to the very low level of adoption that was observed. A favourable change in perception that calliandra could enhance productivity could improve adoption by 0.01 trees and this would include an increase in adoption probability of 0.08 % and an increase in adoption intensity of about 0.002 trees. Being in Manyatta division could increase adoption by 0.01 trees, which would include a 0.07 % increase in adoption probability and an increase in adoption intensity of about 0.002 trees.

4.4.3.3 Factors influencing adoption of calliandra in jointly managed farms (JMF)

With majority of the sampled farm households being jointly managed, results of the determinants of calliandra adoption in the household category were typical of those for the entire sample. Specifically, factors that significantly influenced calliandra adoption in JMF included education, perception that calliandra could improve productivity, extension and participation in on-farm trials (Table 11). Participation in on-farm trials had the expected positive sign and was significant at 1 percent level. As anticipated, extension was positively related to the probability and intensity of adoption and was significant at 5 percent level. Perception that calliandra could improve productivity and education had the predicted positive signs and were significant at 10 percent level.
Table 11: Tobit maximum likelihood estimates and marginal effects of factors influencing adoption of calliandra fodder trees in JMF in Embu District

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. error</th>
<th>Total change in adoption</th>
<th>Change in adoption intensity (trees)</th>
<th>Change in adoption probability (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-31.43***</td>
<td>17.87</td>
<td>-1.33</td>
<td>-0.31</td>
<td>-102.78</td>
</tr>
<tr>
<td>Age of household manager (years)</td>
<td>-0.22</td>
<td>0.21</td>
<td>-0.092</td>
<td>-0.021</td>
<td>-0.11</td>
</tr>
<tr>
<td>Education of household manager (years)</td>
<td>1.57*</td>
<td>0.80</td>
<td>0.67</td>
<td>0.15</td>
<td>5.4</td>
</tr>
<tr>
<td>Size of farm (Acres)</td>
<td>-0.99</td>
<td>1.37</td>
<td>-0.42</td>
<td>-0.097</td>
<td>-3.5</td>
</tr>
<tr>
<td>Number of family farm workers</td>
<td>1.51</td>
<td>1.06</td>
<td>0.64</td>
<td>0.15</td>
<td>4.4</td>
</tr>
<tr>
<td>Index of commercialisation of dairy</td>
<td>6.38</td>
<td>7.84</td>
<td>2.71</td>
<td>0.62</td>
<td>20.16</td>
</tr>
<tr>
<td>Effect of calliandra on productivity (0,1)</td>
<td>11.57*</td>
<td>6.18</td>
<td>4.91</td>
<td>1.13</td>
<td>37.13</td>
</tr>
<tr>
<td>Extension on calliandra (0,1)</td>
<td>12.29**</td>
<td>5.36</td>
<td>5.22</td>
<td>1.20</td>
<td>40.9</td>
</tr>
<tr>
<td>Participation in on-farm calliandra trials (0,1)</td>
<td>28.60***</td>
<td>9.19</td>
<td>12.15</td>
<td>2.79</td>
<td>93.13</td>
</tr>
<tr>
<td>Membership to calliandra group (0,1)</td>
<td>3.41</td>
<td>13.61</td>
<td>1.45</td>
<td>0.33</td>
<td>11.5</td>
</tr>
<tr>
<td>Division (1=Manyatta, 0=Otherwise)</td>
<td>-6.30</td>
<td>5.36</td>
<td>-2.68</td>
<td>-0.62</td>
<td>-20.51</td>
</tr>
<tr>
<td>Restricted Log likelihood function = -188.01</td>
<td>z=0.95</td>
<td>F(z)=0.17</td>
<td>f(z)=0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood function = -163.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood ratio index = 0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model size = 179 observations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***, ** and * = Significant at 1, 5 and 10 percent level respectively.

Source: Author's survey

Marginal effects of explanatory variables on adoption in JMF were much greater than in the male and female managed farms. For instance, participation in on-farm trials increased adoption by 12 trees, which included a 94 percent increase in adoption probability and an increase in adoption intensity of 3 trees. Access to extension improved adoption by 5 trees. This comprised of a 40 percent increase in adoption probability and 1 tree increase in adoption intensity. An extra year of formal education could gave a 0.7 trees increase in adoption, which entailed an increase in adoption probability of 5 percent and an increase in adoption intensity of 0.2 trees. Similarly, a positive change in perception that calliandra could increase productivity improved
adoption by about 5 trees which comprised of a 38 percent increase in probability of adoption and an increase in adoption intensity of 1 tree.

Comparing the results of the Tobit analysis in the three categories of farm households by gender of the manager, the perception that calliandra could improve productivity had a significant influence on adoption in all the three types of households. This shows that the productivity-increasing attribute of the fodder trees is a characteristic that is desired by all farmers. Concomitant with the influence of the perception that calliandra could improve productivity on adoption, majority of farmers who had adopted calliandra had had access to extension information about the fodder trees or had participated in the on farm trials. It can therefore be inferred that access to extension information on calliandra increased the probability and intensity of adoption by favourably influencing farmers’ perception on the benefits of adopting the fodder trees.

Extension was significant in influencing adoption in male and jointly managed farms but not in female managed farms perhaps because in FMF access to extension was too little to initiate adoption. As the results on section 4.3.2 show, among the households that had received extension services on calliandra (extension farm visits and field days and demonstrations), there was a difference in the frequency of access and FMF were the most disadvantaged.
Participation in on-farm trials significantly influenced calliandra adoption in male and jointly managed farms but not in female managed farms. It was also associated with higher positive marginal changes in adoption in the male and jointly managed farms than in the female managed farms. As already indicated, only one FMF participated in the on-farm trials and the variable was therefore not a factor in the regression model for the FMF.

Education was significant in determining the probability and intensity of calliandra adoption in male and jointly managed farms but not in female managed farms. No significant difference existed between the average number of years of formal education of female farm managers and those of their counterparts in male and jointly managed farms. It is likely that factors other than education, for example, perception of the influence of the technology on productivity and climatic conditions were more important in determining adoption behaviour in FMF.
CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and conclusions

Smallholder farmers' account for the bulk of milk produced in Kenya. In the country, women dominate the smallholder farming sub-sector including smallholder dairy production. Unfortunately, dairy productivity in smallholder farms tends to be very low because of poor nutrition of animals. Research has however shown that multipurpose trees such as calliandra could help improve on the quality and quantity of fodder available in the small-scale farms. Subsequently, there has been a lot of interest by scientists to introduce these trees to farmers. Not much is however known about the effectiveness of extension approaches used in the dissemination of this technology and the factors that influence farmers' adoption behaviour. The objectives of the current study were therefore to assess the effectiveness of various dissemination methods in reaching men and women farmers to inform them about the calliandra fodder trees and to determine the factors influencing adoption. Farm households were categorized into male and female-headed households. According to the gender of dairy enterprise manager, the households were further grouped into male, female and jointly managed farms. Descriptive statistics (means and percentages) were used to assess the effectiveness of the dissemination methods while for adoption analysis both
descriptive statistics and econometric analysis (Tobit regression) were used.

Results showed that majority of farmers (66 percent) were aware about the fodder trees. Only 44 percent of farmers in FMF were, however, aware about the trees compared to 92 and 61 percent of their counterparts in the joint and male managed farms respectively. Approaches that had been used in calliandra dissemination in Embu District included four formal methods of extension (on-farm trials, farm visits by extension staff, field days and demonstrations) and the informal method of farmers groups. The informal farmer-to-farmer mode of dissemination also played an important role in the spread of the fodder tree technology in the district.

The formal methods had not been effective in reaching many farmers and were biased against women. Nevertheless, field days and demonstrations were jointly, the relatively most effective methods followed by extension farm visits. In total, 19 percent of farmers had attended some agricultural field days and / or demonstrations where information on calliandra was disseminated while nine percent had received some extension farm visits on the technology. Only 3 percent of the farm households (all of them male-headed) had learnt about calliandra through participation in the on-farm trials. However, by design on-farm trials can only reach a handful of farmers. The trials were however very effective in educating participant farmers about the technology.

At both levels of farm household categorization, women farmers' attendance of field days and demonstrations was lower than that of men. For example,
only 14 percent of farmers in FMF had attended the functions compared to 24 and 18 percent in joint and male managed farms respectively. Moreover, all the managers in FMF who had attended the events had done this only once unlike the case in male and joint managed farms. The farmers in FMF mostly complained that they lacked time to attend the events because they were held when they were very busy. In addition, they tended to be unaware of these events.

For farm visits by extension staff, rarely did the mainly male frontline extension workers visit farmers especially women and when they did they rarely talked about calliandra because they were not aware about the technology. The extension workers downplayed the decision-making role of women and preferred passing on the extension message to men.

Use of women groups as extension contact points in calliandra dissemination enabled more women to be reached. However, access to calliandra planting material through groups as initially intended was constrained by lack of organization on production of own seeds in most of the groups.

Most farmers with calliandra tended to be unaware of the recommended practices of proper utilization of the fodder tree technology. For instance, 71 percent of the calliandra farmers did not know that the calliandra prunings were supposed to be fed to the livestock not more than one hour after cutting. The gender factor influenced the implementation of some of the recommendations by farmers. For example, although most calliandra farmers
were aware that pruning shears was the right implement for harvesting calliandra prunings, they often used a panga. Women who mainly did the pruning in FMF complained that they were very busy and use of pruning shears was too time consuming.

Most farmers in Embu District are yet to start realizing the benefits associated with the calliandra technology because they have not adopted it. Only 16 percent of the sampled farm households were growing the fodder trees and the mean number of trees per adopter household was only 18 percent of the number required if a farmer was to completely substitute calliandra for dairy meal in feeding one dairy animal unit. The low rate of adoption of the technology may be attributed to the ineffectiveness of the dissemination methods.

Results of the Tobit analysis indicated that calliandra adoption in Embu District was significantly influenced by farmers' level of formal education, degree of commercialisation of dairy enterprise, perception that calliandra could enhance productivity, extension and participation in on-farm trials on the fodder trees. The determinants of adoption varied across different gender categories of households. Perception that the fodder trees could increase adoption was however significant in all farm types demonstrating that both men and women farm managers are willing to take up innovations whenever they judge them as being beneficial.

Access to extension was significant in fostering adoption in male and jointly
managed farms but not in FMF possibly because the frequency of access to extension in the FMF was too little to trigger adoption. Similarly, participation in on-farm trials was significant in male and jointly managed farms but not FMF because scarcely any FMF had participated in the trials. It can be concluded that to enhance the rate of adoption of the fodder trees, there is a need to strengthen the extension campaign on the technology and to redesign the dissemination methods in order to ensure their effectiveness in reaching women farmers. By the same token, future on-farm trials on such technologies should strive to bring on board more women farmers.

5.2 Recommendations

- This study has shown that extension was an important determinant of adoption yet the formal methods of extension had not been effective in reaching farmers. Many group and open demonstrations should therefore be conducted to serve as dissemination “nodes” in the diffusion of the fodder tree technology. The demonstrations should be well publicized and held at times and places convenient for most farmers (both men and women) to attend. For greater effectiveness, the extension messages should in addition to informing farmers about the new technology also dwell on how the farmers can access it. The front line extension officers should also be trained on the fodder tree technology so that they can pass this information to farmers when they visit the farmers in their farms. The training about the fodder tree technology should also include more women
extension officers including home economists to provide the extension service to women farmers.

- The farmer-to-farmer exchange of information played an important role in calliandra dissemination. To make sure that farmers deliver correct messages to other farmers, it is important that methods that enhance capacity building at the grass roots level are used. These include participatory dissemination approaches, and working with grass root organizations such as the community based organizations (C B O's) and farmers groups and associations.

- Use of women groups enabled more women to be reached. More women groups should therefore be recruited as calliandra extension groups. Like has been the case in Zimbabwe where groups have been important sources of planting material for maize (Alders, et al, Undated), calliandra groups in Embu should be encouraged to have in place modalities of producing their own calliandra planting material.

- On-farm trials were very effective in educating participant farmers about the technology but only a few farmers could participate. Involvement of more farmers (both men and women) in any future such trials could be realized if the farmers were organized into research groups and researchers work with these groups in conducting the trials. Such an approach has been used by Dry Land Applied Research and Extension
Project (DAREP) in evaluating and disseminating improved technologies in the dry areas of Embu (Kimenye, 1998).

- Farmers perception that calliandra could enhance productivity had a strong positive influence on adoption. Extension demonstrations should therefore have empirical evidence showing the contributions of the fodder trees to productivity and profitability in order to favourably influence farmers' perceptions about this. This would enhance the probability and intensity of adoption.

- Degree of commercialisation of dairy enterprise (as measured by the proportion milk sold) had important positive influence on adoption. Farmers who had difficulties in selling their milk were not motivated to adopt calliandra. Efforts should therefore be made to create efficient milk marketing institutions in the District. For instance, just like in Kiambu and Meru Districts, farmers in Embu District could form strong cooperative societies to oversee the milk processing and marketing activities.

- This study has shown that there was a difference in the effectiveness of extension methods in reaching different gender categories of dairy farmers. The determinants of adoption also differed in different gender categories of farm households. This demonstrates the need for researchers and extension workers to incorporate gender in their works in order to make it more client oriented and effective.
Determinants of adoption of technologies may vary across regions. Findings of this study may therefore not be generalized for the whole country. There is therefore a need for similar studies in other regions.
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Appendices

Appendix (i): Testing for multicollinearity

Partial correlation coefficients

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*** indicates that the correlation is significant at 1 percent level
### Appendix ii: Testing for Heteroscedasticity

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<th>Mean no. years of education of household manager</th>
<th>Average age of household head</th>
<th>Average age of household manager</th>
<th>Mean family farm labour</th>
<th>Mean no. of improved dairy cows</th>
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Numbers in parenthesis are percentages

Legend: MMF= Male managed farms, FMF= Female managed farms, JMF= Jointly managed farms

Source: Authors survey

### (b) Manyatta division

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Numbers in parenthesis are percentages

Legend: MMF= Male managed farms, FMF= Female managed farms, JMF= Jointly managed farms

Source: Authors survey
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<td>44.9</td>
<td>2.7</td>
<td>1.0</td>
<td>0.0</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Numbers in parenthesis are percentages
Legend: MMF = Male managed farms, FMF = Female managed farms, JMF = Jointly managed farms
**Source:** Authors survey
### Appendix iv: Frequency of Extension farm visits on calliandra in different gender categories of households in Manyatta and Runvenjes divisions

#### Manyatta

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Once</th>
<th>Twice</th>
<th>Three or more times</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL HOUSEHOLDS</td>
<td>132 (88)</td>
<td>13</td>
<td>2</td>
<td>3</td>
<td>150</td>
</tr>
<tr>
<td>Male-headed households (MHH)</td>
<td>118 (87)</td>
<td>12</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>MMF</td>
<td>25 (89)</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>JMF</td>
<td>82 (87)</td>
<td>8</td>
<td>1</td>
<td>3</td>
<td>94</td>
</tr>
<tr>
<td>FMF (Defacto)</td>
<td>11 (85)</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Female-headed households (FHH)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMF (De-jure)</td>
<td>14 (93)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>ALL FMF (De facto+ De-jure)</td>
<td>25 (89)</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>28</td>
</tr>
</tbody>
</table>

Numbers in parenthesis are percentages of households that had never received an extension farm visit on calliandra

Legend: MMF = Male managed farms, FMF = Female managed farms, JMF = Jointly managed farms

**Source:** Authors survey

#### Runvenjes

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Once</th>
<th>Twice</th>
<th>Three or more times</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL FARM HOUSEHOLDS</td>
<td>141 (94)</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>150</td>
</tr>
<tr>
<td>Male-headed households (MHH)</td>
<td>128 (93)</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>137</td>
</tr>
<tr>
<td>MMF</td>
<td>28 (90)</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>JMF</td>
<td>79 (93)</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>85</td>
</tr>
<tr>
<td>FMF (Defacto)</td>
<td>21 (100)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Female-headed households (FHH)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMF (De-jure)</td>
<td>13 (100)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>ALL FMF (De facto+De-jure)</td>
<td>34 (100)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>34</td>
</tr>
</tbody>
</table>

Numbers in parenthesis are percentages of households that had never received an extension farm visit on calliandra

Legend: MMF = Male managed farms, FMF = Female managed farms, JMF = Jointly managed farms

**Source:** Authors survey
### Embu District

<table>
<thead>
<tr>
<th>Household category by gender of household head</th>
<th>Men alone</th>
<th>Women alone</th>
<th>Both men and women</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>All households</td>
<td>12</td>
<td>8</td>
<td>7</td>
<td>27</td>
</tr>
<tr>
<td>Male-headed households (MHH)</td>
<td>12</td>
<td>7</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>MMF</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>FMF <em>De facto</em></td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>JMF</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Female-headed households (FHH)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMF <em>De jure</em></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>FMF <em>De facto + De jure</em></td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Legend: MMF = Male managed farms, FMF = Female managed farms, JMF = Jointly managed farms

**Source:** Authors survey
### Appendix vi: Frequency of farmers' attendance to field days and demonstrations where information on calliandra was disseminated in Manvatta and Runvenies divisions

#### Manvatta division

<table>
<thead>
<tr>
<th>Frequency of attendance (percentage)</th>
<th>Zero</th>
<th>Once</th>
<th>Twice</th>
<th>Three times</th>
<th>Four times</th>
<th>Five or more times</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL FARM HOUSEHOLDS</td>
<td>79</td>
<td>13</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>Male headed households (MHH)</td>
<td>78</td>
<td>14</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>MMF</td>
<td>78</td>
<td>11</td>
<td>7</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>JMF</td>
<td>76</td>
<td>17</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>FMF (De facto)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Female-headed households (FHH)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>All FMF (De facto + De jure)</td>
<td>93</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Legend: MMF = Male managed farms, FMF = Female managed farms, JMF = Jointly managed farms

**Source:** Authors survey

#### Runvenies division

<table>
<thead>
<tr>
<th>Frequency of attendance (percentage)</th>
<th>Zero</th>
<th>Once</th>
<th>Twice</th>
<th>Three times</th>
<th>Four times</th>
<th>Five or more times</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL FARM HOUSEHOLDS</td>
<td>82</td>
<td>13</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>Male headed households (MHH)</td>
<td>82</td>
<td>13</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>MMF</td>
<td>87</td>
<td>10</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>JMF</td>
<td>77</td>
<td>18</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>FMF (De facto)</td>
<td>95</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Female-headed households (FHH)</td>
<td>85</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>All FMF (De facto + De jure)</td>
<td>91</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Legend: MMF = Male managed farms, FMF = Female managed farms, JMF = Jointly managed farms

**Source:** Authors survey
Appendix vii: Farm Household Survey Questionnaire

DISSEMINATION AND ADOPTION OF IMPROVED FODDER TREES: THE CASE OF CALLIANDRA CALOTHYRSUS IN EMBU DISTRICT, KENYA.

Date of interview...........................................

Name of the respondent.............................................. Sex...............................

Relationship with the household head..............................

1.0 FARM IDENTIFICATION

Division.............................. Location.................................

Sub-location......................... Farm number............................

Distance from the main road ......Km Distance from the nearby buying centre.........Km

2.0 INFORMATION ABOUT THE HOUSEHOLD

2.1 Name of the household head.............................................. Gender........

Age .............

2.2 Level of education........................................

2.3 Main occupation i.e. farmer / Others (specify)..........................

2.4 Marital status i.e. single/married/window/widower (tick the collect one).

2.5 If the household head is married in 2.4 above, what is:

   (i.) The age of the spouse...........

   (ii.)Years of education of the spouse ..........

   (iii.)The main occupation of the spouse ..........

2.6 Does the household head live on the farm? Yes/ No.

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3.0 FARM CHARACTERISTICS

3.1 What is the size of the farm? .................. acres

3.2 Do you have a title deed? Yes / No.

3.3 Do you have some other pieces of land? Yes/ No. If yes, what is the size, and form of ownership, date of acquisition, of each piece.

<table>
<thead>
<tr>
<th>Size in acres</th>
<th>Form of ownership i.e. private or rented</th>
<th>Date of acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.0 ENTERPRISES IN THE FARM

4.1 Crop enterprises

<table>
<thead>
<tr>
<th>Type of enterprise</th>
<th>Acreage</th>
<th>Ranking in terms of importance by the farmer</th>
</tr>
</thead>
<tbody>
<tr>
<td>i Cash crops (a.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b.) Tea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii Food crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(maize, beans etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii Horticulture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(tomatoes, cut-flowers, cabbages etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv Other crop enterprises</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2 Dairy enterprise

4.3 When did you start keeping dairy animals? .................. year

4.4 How many milking cows do you have? .......................

For each milking cow, what is the age, breed, number of times it has calved down and average milk production per day?.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Age</th>
<th>Breed</th>
<th>Number of times the cow has calved down</th>
<th>Average milk production per day (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Morning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.5 Does the farmer have some dairy goats? Yes / No. If yes , how many? ...........

4.6 What is the average amount of milk consumed in the household per day? ......litres.

4.7 What is the average amount of milk sold per day to: (i.) K.C.C....... litres

(ii.) Locally......litres

4.8 Who receives the cash from milk sales i.e. M/ F / both / others

(specify).................

4.9 How many of each of the following other categories of cattle does the farmer have?

<table>
<thead>
<tr>
<th>BREEDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category of animal</td>
</tr>
<tr>
<td>Heifers</td>
</tr>
<tr>
<td>Bulls &amp; oxen</td>
</tr>
<tr>
<td>Female calves &lt; 1 yr</td>
</tr>
<tr>
<td>Male calves &lt; 1 yr</td>
</tr>
</tbody>
</table>

F= Friesian  A= Aryshire  J= Jersey  G= Guernsey

4.10 Who makes the following decisions in dairy?

<table>
<thead>
<tr>
<th>Type of decision</th>
<th>Decision maker M /F / Both / Others(specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of milk to consume and to sell</td>
<td></td>
</tr>
<tr>
<td>How to use cash from milk sales</td>
<td></td>
</tr>
<tr>
<td>Buying of animals</td>
<td></td>
</tr>
<tr>
<td>Selling of animals</td>
<td></td>
</tr>
<tr>
<td>How to use cash from animal sales</td>
<td></td>
</tr>
<tr>
<td>How to use the manure</td>
<td></td>
</tr>
</tbody>
</table>
4.11 Who does the following activities in the dairy enterprise in the farm?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Person doing the activity M/ F / Both / Others (specify) .................</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i.) Feeding the animals</td>
<td></td>
</tr>
<tr>
<td>(ii.) Watering the animals</td>
<td></td>
</tr>
<tr>
<td>(iii.) Milking</td>
<td></td>
</tr>
<tr>
<td>(iv.) Delivering the milk to the</td>
<td></td>
</tr>
<tr>
<td>milk buying centre</td>
<td></td>
</tr>
</tbody>
</table>

4.12 In general, who is responsible for the management of the dairy enterprise in the farm? M / F / Both / Others (specify)

4.13 What other animal enterprises are there in the farm?

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>No. of Animals</th>
<th>Purpose i.e. cash or subsistence</th>
<th>Ranking in terms of importance by the farmer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Small ruminants i.e. goats &amp; sheep</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Pigs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Poultry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Others (specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.0 FARM LABOUR SUPPLY

5.1 What is the number of male and female members of the household working fulltime and part time on the farm.

<table>
<thead>
<tr>
<th>Full time workers</th>
<th>Part time workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
<td>Female</td>
</tr>
</tbody>
</table>

5.2 Do you have any permanent farm labourers? Yes / No. If yes:

(i.) How many?.............

(ii.) On which enterprises do they work?

   (a) Cash-crops e.g. coffee and tea
   (b) food crops
   (c) dairy
5.3. Do you hire any casual labourers? Yes / No. If yes, how many? ............

For what farm operations? ............................................................

............................................................

6.0 ANIMAL FEEDING AND FODDER PRODUCTION

6.1 What type of dairy feeding system is practised in the farm?

(i.) Purely stall feeding (zero grazing)  (ii.) Stall feeding plus grazing

(iii.) Grazing only

6.2 Do you have some pure stand napier plot/plots? Yes / No. If yes, what is the total area of the farm covered by the pure stand napier plot/plots? ............. acres

6.3 What is the total length of the bands planted with napier? ......... metres

6.4 Do you grow Lucerne, desmodium or any other type of improved forages? Yes / No. If yes go to 6.5. If no, go to 6.6.

6.5 What is the acreage of each of these type of improved fodder crops.

<table>
<thead>
<tr>
<th>Type of improved forage crop</th>
<th>Size (acres) of land under the forage crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucerne</td>
<td></td>
</tr>
<tr>
<td>Desmodium</td>
<td></td>
</tr>
<tr>
<td>Others -</td>
<td></td>
</tr>
</tbody>
</table>

6.6 What is the reason for not growing the improved forages?

(i.) Small size of the land

(ii.) Lack of awareness

(iii.) Lack of cash to buy the planting material

(iv.) Other reasons (specify) ..............................
6.7 Who makes the following fodder crops planting decisions?

<table>
<thead>
<tr>
<th>Type of decision</th>
<th>Decision maker M / F / Both / Others (specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of fodder crop to plant</td>
<td></td>
</tr>
<tr>
<td>Where to plant fodder crops on the farm</td>
<td></td>
</tr>
<tr>
<td>Size of land planted with fodder crops</td>
<td></td>
</tr>
</tbody>
</table>

6.8 Who does the following activities in fodder production in the farm?

<table>
<thead>
<tr>
<th>Activity</th>
<th>M / F / Both / Others (specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i.) Planting fodder crops</td>
<td></td>
</tr>
<tr>
<td>(ii.) Weeding</td>
<td></td>
</tr>
<tr>
<td>(iii.) Manuring</td>
<td></td>
</tr>
<tr>
<td>(iv.) Cutting</td>
<td></td>
</tr>
</tbody>
</table>

6.9 Do you always have enough fodder for your animals throughout the year? Yes / No. If No, go to 6.10.

6.10 (i.) During which months do you usually experience severe fodder shortage?

(ii.) How do you address the fodder shortage problem

(a) Buying fodder

(b) Using more concentrates (bran)

(c) Utilising weeds to feed the animals

(d) Other ways (specify) .................................................................

6.11 Do you give your animals dairy meal? Yes / No.

6.12 If yes, to which categories of animals do you feed the dairy meal and what is the average amount given per animal per day?

<table>
<thead>
<tr>
<th>Type of animal</th>
<th>Average amount of dairy meal / animal / day</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i.) Milking cows</td>
<td></td>
</tr>
<tr>
<td>(ii.) Heifers</td>
<td></td>
</tr>
<tr>
<td>(iii.) Calves</td>
<td></td>
</tr>
</tbody>
</table>
6.13 Who decides whether or not to buy the dairy meal? M / F / both / others
(specify) ........................................................................................................

6.14 Who buys the dairy meal? M / F / both / others (specify) .........................

6.15 Are you able to give your animals dairy meal throughout the year? Yes / No. If
No, go to 6.16.

6.16 What is the main reason as to why you are not able to give your animals dairy
meal throughout the year?
(i.) Lack of cash
(ii.) Milk disposal problems
(iii.) The feeds are not available in the shops
(iv.) Other problems (specify) ............................................................................

6.17 What are the major problems encountered by farmers in this district in using
dairy meal to supplement their animals?
(i.) High cost of dairy meal
(ii.) Variability in quality of the feeds
(iii.) Lack of credit facilities
(iv.) Other problems
(specify) ........................................................................................................

..........................................................
6.18 What could you say are the major problems facing the smallholder dairy farmers in this district?

(i) Livestock diseases
(ii) Lack of organised marketing channel for milk.
(iii) Delayed payment for milk.
(iv) High cost of feeds

7.0 INFORMATION ABOUT FODDER TREES.

7.1 Have you ever heard about calliandra fodder trees? Yes / No.

7.2 If yes, (i.) When did your first hear about them? .......... year.

(ii) From what source:

(a) Research
   (i.) On-farm trials      (ii.) Research station

(b) Extension
   (i.) Farm visits by extension staff (iv.) Farmers training
   (ii.) Self help group (v.) visits to other farmers
   (iii.) Field day

(c) Other sources (specify) .................................................................

7.3 Can feeding calliandra affect milk production? Yes / No. If yes, how would milk production be affected? (i.) Increase  (iii.) Decrease

7.4 Can feeding calliandra have any effect on the quality of milk? Yes / No. If yes, how would the milk quality be affected? (i.) Improve (ii.) Decline (Tick the collect one)
7.5 Do you have any calliandra fodder trees? Yes/No.

If yes, in which locations of the farm are the trees planted and how many trees are planted in each of these locations.

<table>
<thead>
<tr>
<th>Location</th>
<th>No. of trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Inline on contours</td>
<td></td>
</tr>
<tr>
<td>(b) Inter-cropped with cash and food crops.</td>
<td></td>
</tr>
<tr>
<td>(C) Homestead boundary</td>
<td></td>
</tr>
<tr>
<td>(d) Inter-cropped with napier grass</td>
<td></td>
</tr>
<tr>
<td>(e) External boundary</td>
<td></td>
</tr>
<tr>
<td>(f) Internal boundary</td>
<td></td>
</tr>
</tbody>
</table>

7.6 How did you obtain your planting material?

(i.) Given by National Dairy Development Project or National Agro-forestry Research Programme.

(ii.) Bought

(iii.) Given by other farmers

(iv.) Other sources (specify).................................

7.7 Do you have any other kind of fodder trees? Yes/No. If yes, go to 7.8

7.8 What is the type and the number of the trees?

<table>
<thead>
<tr>
<th>Type of tree</th>
<th>Number of trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

7.9 Who makes the following fodder tree planting decisions?

<table>
<thead>
<tr>
<th>Decision</th>
<th>Decision maker( M/F/Both/Others (specify))..............................</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whether to plant fodder trees</td>
<td></td>
</tr>
<tr>
<td>Number of fodder trees to plant</td>
<td></td>
</tr>
<tr>
<td>Farm locations where the fodder trees are to be planted</td>
<td></td>
</tr>
</tbody>
</table>
7.10 Who does the following activities related to the fodder trees management?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Done by M /F/ both/ Others (specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Plating of the fodder trees</td>
<td></td>
</tr>
<tr>
<td>2 Watering the fodder trees,</td>
<td></td>
</tr>
<tr>
<td>3 Weeding</td>
<td></td>
</tr>
<tr>
<td>4 Manuring</td>
<td></td>
</tr>
<tr>
<td>3 Cutting</td>
<td></td>
</tr>
</tbody>
</table>

7.11 (a) What is the recommended cutting height of calliandra? .................

(b) At what height do you cut your calliandra trees? ....................

(c) What is the recommended implement for cutting? ....................

(d) What implement do you use to prune your calliandra trees? ............

(e) Does feeding calliandra long after cutting matter? Yes / No. If yes, explain

........................................................................................................

(f) How long after cutting do you feed calliandra to your animals? ......hrs

(g) What is the recommended amount of calliandra that a milking cow should be fed? ........................................

(h) (i.) How much calliandra do you give per animal per day? ............... If the amount is different from the recommended, why do you give a different amount from the recommended? ........................................

........................................................................................................

(ii.) How do you measure the amount of calliandra that you feed to your animals? (explain).................................................................
7.12 Do you feed calliandra to your animals throughout the year. Yes /No. If no, what is the reason as to why you are not able?

(i.) Lack of enough trees

(ii.) Failure by the trees to produce enough prunings during the dry season

(iii.) Other reasons (specify). .................................................................

7.13 Are there some other benefits that you can say you get from calliandra? Yes / No. If yes, specify .................................................................

7.14 How does calliandra fodder trees in the farm affect other crops and why?

<table>
<thead>
<tr>
<th>Effect on crops</th>
<th>Farmers explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td></td>
</tr>
<tr>
<td>No effect</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td></td>
</tr>
</tbody>
</table>

7.15 Do you harvest seeds from your calliandra trees? Yes / No. If yes go to 7.16

7.16 What do you do with the seeds?

(i.)Plant 

(ii.)Sell

(iii.)Gives to friends and relatives (iv.)Others uses (specify) ..............

7.17 From at least how many calliandra trees is a farmer supposed to collect seeds for planting? ......................

7.18 Would you like to increase the number of your calliandra trees? Yes / No. If yes go to 7.19.

7.19 What are the problems limiting your expansion of calliandra?

(i.) Availability of planting material (ii.) Lack of cash to purchase the planting material.

(ii.) Lack of knowledge on how to propagate from own seeds

(iii.) Others (specify) .................................................................
8.0 INFORMATION ON FARMERS ACCESS TO EXTENSION INFORMATION.

8.1 Has your farm ever been visited by extension staff to teach you any improved farming methods. Yes / No. If yes,

i. How many times was the farm visited last year? ..................

ii. If the farm was not visited last year, when was it last visited? ..........

iii. Has the farm ever been visited by extension staff to teach you about calliandra fodder trees? Yes / No If yes, go to 8.1(iv.)

iv. When did the visit/ visits take place and what did the extension staff talk about each time they visited?

<table>
<thead>
<tr>
<th>Visit</th>
<th>Date of the visit</th>
<th>Subject addressed by the extension officer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

v. Who normally talks to the extension officers when they come to the farm? M / F / Both / Others (specify) ................................................

vi. Have you ever visited some other calliandra farmers so as to learn about the fodder trees? Yes / No. If yes, how many times? ............

8.2 Have you ever participated in any on-farm calliandra trials? Yes / No. If yes,

i. Did you increase or reduce the number of your calliandra trees after the trials?

ii. What was the reason for increasing, reducing or not changing the number of your calliandra trees after the trials? ............................

.................................................................
To be answered by the Man for the case of Male-Managed and Jointly-Managed Households

8.3 Have you ever attended any agricultural extension field day or demonstration? Yes / No. If yes, go to 8.4.

8.4 (i) Do you still attend them? Yes / No. If yes, how frequently can you say you attend this functions i.e. regularly / not regularly (underline the collect one).

(ii) Have you ever attended any extension field day or demonstration organised to teach farmers about calliandra. Yes / No. If yes, how many times? ................. If no, what are the reasons for not attending?

(a.) Lack of awareness

(b.) Lack of time because they are held when I am busy

(c.) They are held far from home

(d.) Lack of transport

(e.) Other reasons (specify) .................................................................

8.5 Are you a member of any informal group/ groups? Yes / No. If yes,

What is the name of the group/ groups? ............................................

(i) What activities do this group/ groups engage in? .........................

...........................................................................................................

(ii) Have you ever received any extension information through the group/ groups? Yes / No. If yes, go to (iii)

(iii) On what issue was this information about?

(a.) Calliandra

(b.) Others issues (specify) ...............................................................
(iv) How else can you say the group has helped you in farming?.............

.................................................................

8.6 Which of the following extension method do you think would be most appropriate for you and what modifications would you suggest for other methods?

<table>
<thead>
<tr>
<th>Extension method</th>
<th>Preferred method</th>
<th>Suggested modifications to other methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual farm visits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field days &amp; seminars</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmers training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm trials</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To be Answered by the Woman for the case of Female Headed, Female Managed and Jointly Managed Households

8.7 Have you ever attended any agricultural extension field day or demonstration?

Yes / No. If yes, go to 8.8.

8.8 (i) Do you still attend them? Yes / No. If yes, how frequently can you say you attend this functions i.e. regularly / not regularly (underline the collect one).

(ii) Have you ever attended any extension field day or demonstration organised to teach farmers about calliandra. Yes / No. If yes, how many times? ............

If no, what are the reasons for not attending?

(a.) Lack of awareness

(b.) Lack of time because they are held when I am busy

(c.) They are held far from home

(d.) Lack of transport

(e.) Other reasons (specify).................................................................

8.9 Are you a member of any informal group/ groups? Yes / No. If yes,
What is the name of the group/groups? ..............................

(v) What activities do this group/groups engage in? ..............

........................................................................................................

(vi) Have you ever received any extension information through the group/groups? Yes / No. If yes, go to (vii)

(vii) On what issue was this information about?

(a.) Calliandra

(b.) Others issues (specify)..............................................................

(viii) How else can you say the group has helped you in farming? .......

........................................................................................................

8.10 Which of the following extension method do you think would be most appropriate for you and what modifications would you suggest for other methods?

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