ꞁN ECONOMIC ANALYSIS OF FACTORS AFFECTING ꞁHE ADOPTION OF NAPIER GRASS IN SMALLHOLDER ꞁAIRYING IN KIAMBU DISTRICT, KENYA

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DECLARATION

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

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To my family: for your high expectations

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ABBREVIATIONS AND CONVERSIONS

Abbreviations

AI = Artificial Insemination

Ha = hectare

ILRI = International Livestock Research Institute

KARI = Kenya Agricultural Research Institute

Kshs = Kenya shillings

MoADLM = Ministry of Agriculture, Livestock Development and Marketing

NDDP = National Dairy Development Project

SDP = Smallholder Dairy Project

US$ = United States dollar

Yr = year

Conversions

1 hectare = 2.47 acres

1 hectare = 10,000 M^2

ABSTRACT

This study focused on the smallholder dairy farmers in Kiambu district. The aim of the study was to assess the factors that influence farmers' decision to adopt Napier grass and to quantitatively evaluate the impact of these factors on the adoption of planted fodder. It also aimed at recommending policy interventions that may be used to enhance the adoption of planted fodders for improved dairy production in Kenya.

Data were collected in two phases through questionnaire interviews with Kiambu farmers in 1996 and 1997 and subjected to descriptive and quantitative analyses. The results of the descriptive analysis showed that the Napier grass adopters constituted 70% of the agricultural households in the sample. The adopting households had more educated heads and endowed with more farm resources (land and cattle) than the non-adopting households. The sample households sold Napier grass, maize stover, cut grass and banana stems in informal fodder markets where the type, seasonal availability and the quantity of fodder bought determined the prices. An opportunity cost analysis carried out using the 1997 data indicated that farmers in the sample would obtain more returns if they devoted their land to maize rather than to Napier production.

The quantitative analysis used three econometric models to evaluate factors that influence the probability and the level of adoption of Napier grass among the smallholder farmers in Kiambu district. The results showed that the probability of adoption of Napier grass was positively influenced by the years of farming experience of the household head, belonging to the horticulture/dairy zone, off-farm employment, and belonging to a dairy co-operative/farmer organisation. Milk price negatively influenced the probability of adoption of Napier grass among the sample farmers. On the other hand, years of farming experience of the household head, belonging to the horticulture/dairy zone, land and cattle herd sizes, and extension advice on planted fodder had a positive impact on the level of adoption of Napier grass. Years of education of the household head had a negative effect on the level of adoption among the study farmers. The probability and the level of adoption of Napier grass were jointly influenced by the farming experience of the household head, land and

cattle herd sizes, off-farm employment and co-operative/farmer organisation membership. In general, membership in a dairy co-operative/farmer organisation had the greatest impact on both the probability and the level of adoption of Napier, probably highlighting the importance of these organisations in the diffusion of agricultural technologies in Kiambu district. In all fitted models, the sex of the household head had no impact on either the probability or the level of adoption of Napier.

Two policy recommendations were made based on the findings of this study. First, there is need to support and strengthen the existing dairy co-operative societies/farmer organisations to enable them fully participate in dairy development not only in Kiambu district but also in other dairy producing areas in Kenya. Second, the extension service should use contact farmers and encourage farmer-to-farmer exchanges to increase the adoption of planted forages in other areas of Kenya.

CHAPTER ONE

INTRODUCTION

1.1 Background

1.1.1 Development of smallholder dairying in Kenya - A historical perspective

Kenya's dairy production from exotic grade and cross-bred cattle dates back to the pre-independence era when the then White Highlands (now parts of Rift Valley and Central provinces) were occupied by white settlers. These white settlers kept exotic dairy breeds imported from Europe in the 1920s (Stotz, 1979). The breeds, which included Ayrshire, Friesian, Guernsey and Jersey, were reared in large-scale farms under extensive grazing. At independence in 1963, the 0.7 million hectares of high potential farmland that were hitherto occupied by the white settlers were sub-divided into about 50,000 smallholdings for African settlers (Stotz, *op. cit.*). The dairy herds on large farms were also sold to the smallholder African settlers. Over the years, smallholder dairy farming has grown considerably and today it contributes over 70% of the country's marketed milk output (Omiti *et al.*, 1993), valued at about US$ 400 million[1] (Peeler and Omore, 1997).

The impetus for the growth of Kenyan smallholder dairying was the set of policy reforms promulgated by the Swynnerton Plan of 1954. These reforms included the adjudication and consolidation of land to individual ownership, the introduction of cash crops (mainly coffee, tea and pyrethrum) in African farms and the advancement of credit to African farmers to purchase grade dairy cows (Stotz, *op. cit*). The land reform enabled farmers to fence their grazing land and fallows. The credit and income generated from the sale of cash crops was used to purchase dairy grade cows. In addition, credit was also invested on dairy-related farm improvements. The Swynnerton Plan also proposed the establishment of a service structure for smallholder dairying. These services included communal dips, feeder roads, milk collection centres and artificial insemination (AI). These reforms contributed to the growth of dairy cattle

[1] At Kshs 60 to the US dollar.

population in African smallholdings in Kenya from 80,000 head in 1960 to about three million head today, thus making Kenya's dairy sector one of the largest in sub-Saharan Africa (MoALDM, 1995).

1.1.2 Characteristics of smallholder dairying in Kenya

Smallholder dairying in Kenya is concentrated in the high agricultural potential areas of Central, Rift Valley, Western and Eastern (around Mt. Kenya) provinces. These areas correspond to the 1500-2500 metre altitude and 1200-2000 mm isohyet. Due to their high agricultural productivity, these areas hold the bulk of the country's human population and about 80% of the dairy cattle population (Wakhungu, 1996). Expectedly, these areas are also the milk surplus regions of Kenya (MoALDM/KARI/ILRI, 1997).

Farmers in these areas keep an average of two cows and their followers per household under semi-zero or zero grazing systems[1]. Land sizes average one hectare per household and livestock keeping is integrated with crop production (Omore, 1996). The most common dairy breeds kept are Friesian, Ayrshire, Guernsey, Jersey and their crosses, though the latter constitute the bulk of the dairy herd (MoALDM, 1995). The major cash crops grown include coffee, tea, pyrethrum and a variety of horticultural crops. Maize, beans and bananas are some of the major food crops grown.

Apart from proceeds from cash crops and periodic sales of surplus subsistence crops, the dairy enterprise contributes a significant proportion of the household income not only through daily milk off-take but more significantly in the provision of a cheap source of milk for household consumption (Winrock International, 1992). In a country where the main staples are predominantly starchy and with the ever-increasing cost of meat, milk offers an alternative source of dietary proteins to a majority of Kenyans. Although the main intent of keeping dairy cattle in smallholder farms is to produce milk for household consumption, surplus milk is sold to either neighbours, milk vendors or local dairy co-operatives (Staal *et al.*, 1997).

[1] Zero grazing differs from semi-zero grazing by the absence of pasture and higher levels of input use, including dairy meal and cultivated fodder, especially Napier grass (see details in Chapter Two).

An essential characteristic of smallholder dairying is that much of the labour is provided by members of the family, although some workers may be hired (Ruthenberg, 1985). In the absence of hired labour, the wife and children do most of the dairy related activities like gathering fodder and milking. In male-headed households, the husband has control over much of the income derived from the dairy enterprise (Staal *et al.*, 1998).

More often than not, the dairy enterprise in smallholder farms is poorly managed. Poor management in these farms is indicated by high calf mortality of up to 20% in suckling calves (Peeler and Omore, 1997); slow growth rate resulting in delayed maturity and subsequent delayed age at first calving of up to 41 months (Omore, 1997); poor breeding programmes as characterised by low use of artificial insemination (AI) (especially now that the Government has withdrawn from AI services), and the fact that heifers are not served until they are over 32 months of age (Peeler and Omore, 1997); poor fertility as indicated by long calving intervals and low conception rates; and, long lactation lengths (of up to 16 months) with lactation yields as low as 2500 kgs per cow (or about 5 kgs of milk/cow/day), thus giving lactation curves that collapse soon after calving (Tanner *et al.*, 1998).

One of the main factors characterising smallholder dairying is its reliance on diverse sources of fodder. Fodder is either cultivated, gathered or purchased outside the farm. Among the cultivated fodders is the high biomass-yielding Napier grass (*Pennisetum purpureum*) and forage legumes such as *Desmodium, Leucaena* and *Calliandra*. In most cases, fodder (e.g. garden weeds and grass) is gathered on or off the farm, from road reserves and neighbours' farms, or purchased from either neighbours or established roadside fodder markets. Crop residues, such as maize stover, wheat straw, bean haulms, sweet potato vines, banana residues and waste from horticultural products, complement cultivated fodders. Supplementation with commercial feeds, such as dairy meal, maize germ and wheat bran, and, occasionally, brewer's waste, is usually done at milking. Since the drought of 1984, poultry waste has increasingly been used as a feed supplement in smallholder dairy farms (Odongo *et al.*, 1998).

Apart from milk and beef products, manure is the other major output from livestock production. In the smallholder dairy systems of Kenya, manure substitutes for expensive inorganic fertilisers to replenish soil fertility. It thus acts as a major link between livestock and crop production systems (McIntire *et al.*, 1992).

1.1.3 Constraints to smallholder dairying in Kenya

The Government of Kenya, through the Ministry of Agriculture, Livestock Development and Marketing (MoALDM), has identified several constraints that hamper the growth and development of the country's dairy sub-sector. These problems, although not entirely unique to the country's smallholder dairy farming, can be broadly classified into two categories, namely (i) production and (ii) marketing constraints (MoALDM, 1995):

1.1.3.1 Production constraints

The production constraints that seem to interfere with the development of smallholder dairying in Kenya include (a) inadequate quality and quantity of feed, (b) poor disease control and frequent occurrence of tick-borne diseases, (c) inefficiency in breeding services (e.g. AI service) and lack of adequate quality breeding stock, (d) lack of suitable dairy credit, (e) reduced land resource as a result of high human population, (f) unfavourable input/output ratios for the dairy enterprise, (g) poor management/husbandry for the dairy cattle, (h) high cost of concentrate feeds, and (i) declining levels of soil fertility due to over-cropping and low fertilisation as a result of low incomes.

1.1.3.2 Marketing constraints

The marketing constraints affecting the dairy sub-sector include (a) poor rural road infrastructure, (b) lack of milk cooling facilities, (c) inefficient dairy marketing organisations, especially the dairy co-operatives, (d) lack of and/or poor marketing information for both input and output prices, and (e) lack of appropriate agricultural technologies adapted to smallholder dairy production and small-scale processing.

1.1.4 Prospects for smallholder dairying in Kenya

Since independence, the Government of Kenya has actively pursued a policy of encouraging smallholder dairy development, focusing its efforts on harvesting surplus milk from the high potential highland areas of Kenya (Mullins, 1995). The annual rate of growth of the country's human population and urbanisation are respectively estimated to be about 2.5% and 23% by the year 2001 (GoK, 1997). The liberalisation of the dairy industry, increased human population, urbanisation and growth in income will likely change the people's consumption profiles and thus stimulate an upward shift in the country's milk demand pattern. Given that smallholders are the major producers of milk in Kenya (Omiti *et al.*, 1993), then these changes will necessarily be in favour of the smallholder dairy producers. There is, therefore, potential for growth of the country's dairy sub-sector, particularly smallholder dairying. However, the full realisation of this growth will be determined by how well the country tackles the constraints (already cited) that impinge on dairy development. This will require concerted efforts of all stakeholders in dairy development - farmers, extension workers, researchers, policy makers and/or implementers and donors - to come up with workable solutions that will revitalise the growth and development of this sub-sector. This will be possible only if the parties involved have the right information on key issues that influence the performance of the country's dairy industry. This information will only come from well focused dairy research.

1.2 Problem statement

Limited feed availability and poor reproductive management have been cited as the major drawbacks to milk production in the Kenyan dairy sub-sector (Omore *et al.*, 1994; Odima *et al.*, 1994; Winrock International, 1991; Stotz, 1983). Omore *et al.* (1994) and Wandera *et al.* (1996) observed that it is the inadequate quantity and quality of available feeds that mostly constrain dairy production, especially among the smallholder dairy farmers in Kenya. A recent report by the ILRI's Smallholder Dairy Project (SDP) indicates that the demand for dairy products will rise to about 5.8 billion metric tonnes (MT) by the year 2010, 15% higher than the projected production of about 5 billion MT (MoALDM/KARI/ILRI, 1998). The projected demand and production gap is due to Kenya's high rate of population growth of 3.3% per annum and a reduced rate of growth of the dairy herd. Most of the projected increases in demand for marketed milk will be in urban areas, where on average, incomes and population growth rate are higher than in the rural areas. These factors make the constraints of dairy production in Kenya to be of great concern.

Over the years, several fodders that produce adequate quantities of good quality herbage have been identified and their importance in dairy farming promoted through extension efforts (Reh, 1996). One of these fodders is Napier grass (*Pennisetum purpureum*), a high biomass yielding species of graminae family. High human population pressure in the high agricultural potential areas of Kenya has led to appreciable competition for land between humans and livestock. This has led to high rates of adoption of Napier grass by dairy farmers in some highland districts and especially Kiambu district (Staal *et al.*, 1997). The high rate of adoption of Napier grass in Kiambu district allows for a close examination of the factors that influence the probability and the level of adoption of planted fodder, both jointly and independently. This study was carried out to quantitatively evaluate factors that influence farmers' decision to adopt Napier grass in Kiambu district, with a view to understanding the mechanisms of adoption of planted forages. This understanding could assist efforts to promote planted fodder (whether Napier or herbaceous legumes) in other highland areas of Kenya where these fodders have not been widely adopted.

1.3 Justification of the study

The development and utilisation of agricultural technologies are important prerequisites of economic development as they raise the production possibility frontier of agricultural commodities. Agricultural technology is therefore a 'cutting edge' to economic development, especially for countries with agro-based economies. Without agricultural technologies the scope for increasing agricultural production and rural incomes is very limited. However, while technological advancement is necessary for agricultural development, it is not a sufficient step towards increased agricultural production *per se* unless adopted. Studies by Rogers (1962), Leagans (1979) and Adesina and Zinnah (1993) have shown that farmers have certain attitudes and perceptions that condition their acceptance and subsequent utilisation of agricultural technologies. Farmers' technology adoption decisions are shaped by the personal, economic, socio-cultural and environmental influences under which they operate. Consequently, for any agricultural technology to have an impact on farmers' productivity and thus welfare, the factors that influence its adoption should be well understood. Such an understanding forms an important basis for any attempt at introducing change into smallholder farming systems.

Studies on dairy cattle production conducted in Kenya and elsewhere have mainly addressed the question of the quality and quantity of feed needed for maintaining the body and milk production of the dairy animal. Agronomic studies (e.g. Anindo and Potter (1994) and Karanja (1981)), on the other hand, have biased their attention to the agronomic factors necessary for the production of fodder crops. Review of existing adoption literature so far reveals no study that has analysed quantitatively the mechanisms of fodder adoption in Kenya and hence the need for this study.

1.4 Objectives of the study

1.4.1 Broad objective of the study

The broad objective of this study was to evaluate the factors that influence the adoption of Napier grass in the high agricultural potential dairy farming systems of Kenya.

1.4.2 Specific objectives

The specific objectives of this study were:

- to identify the factors that influence farmers' decision to adopt Napier grass as an animal feed in smallholder dairying in Kiambu district;
- to quantitatively evaluate the impact of these factors on the adoption of Napier grass; and
- to recommend policy interventions that may be used to enhance the adoption of Napier grass as an animal feed in other areas of Kenya with dairy farming potential.

1.5 Hypotheses tested in the study

The hypotheses that were tested in this study were:

1. Farmer's decision to adopt Napier grass in smallholder dairying in Kiambu district is significantly influenced by farmer's household characteristics.
2. Farmer's decision to adopt Napier grass in smallholder dairying in Kiambu district is significantly influenced by farmer's resource attributes.
3. Farmer's decision to adopt Napier grass in smallholder dairying in Kiambu district is significantly influenced by market factors.
4. Farmer's decision to adopt Napier grass in smallholder dairying in Kiambu district is significantly influenced by institutional factors.
5. The level of adoption of Napier grass in smallholder dairying in Kiambu district is significantly influenced by farmer's household characteristics.
6. The level of adoption of Napier grass in smallholder dairying in Kiambu district is significantly influenced by farmer's resource attributes.
7. The level of adoption of Napier grass in smallholder dairying in Kiambu district is significantly influenced by market factors.
8. The level of adoption of Napier grass in smallholder dairying in Kiambu district is significantly influenced by institutional factors.

1.6 Study area

1.6.1 Geographic location, demography, administration and agro-ecological zones

This study focuses on the smallholder dairy farming systems of Kiambu district, one of the central highland districts of Kenya. The district spans over the 0° and 25° south latitudes and the 36° 30" and 37° east longitudes. With an altitude of 1,350-2,400 metres above sea level, it borders Nairobi and Kajiado districts to the south, Nyandarua and Nakuru districts to the north and to the west respectively. The newly created Thika district was curved out of Kiambu and now lies to its east (See Figure 2).

According to the Central Bureau of Statistics (CBS) (1995), the old Kiambu had a population of about 914,000 persons in the 1989 census or a population density of 353 persons per square kilometre. With a projected national population growth rate of about 3.3% per annum, the district will have about 1.3 million people by the year 2000 (GoK, 1997). The new Kiambu district is divided into five administrative divisions, namely, Lari, Githunguri, Kiambaa, Limuru and Kikuyu (See Figure 2).

Kiambu district has a bimodal rainfall pattern. Long rains come between March and May and short rains between October and December. The average annual rainfall is 1100 mm, ranging from 600 to 2,500 mm between the south and the northwestern parts of the district. The temperature range is 10°-25°C, depending on altitude. The soils are predominantly nitosols, commonly called the Kikuyu red loam (Ikombo *et al.*, 1996).

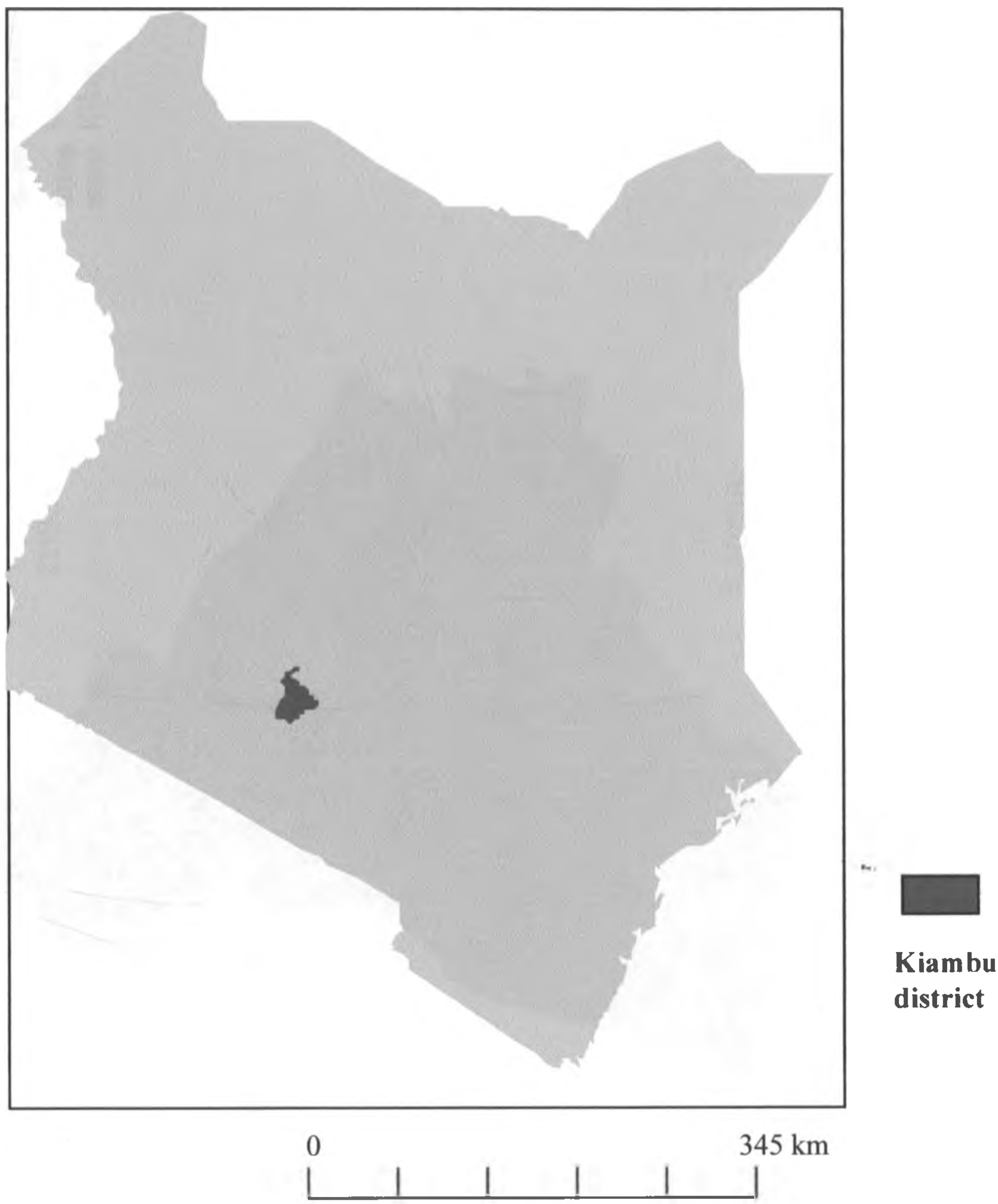
Jaetzold and Schmidt (1983) classified Kiambu district into four agro-ecological zones as summarised in Table 1.1 and illustrated on Figure 3 below. The map of the new Kiambu district excludes the lower midland zone (LM4-5).

Table 1.1: Agro-ecological zones of the old Kiambu district

Zone	Code	Characteristics
Upper highland zone	UH0-2	Bordering the Aberdare range, it has forest, sheep/dairy and pyrethrum/wheat sub-zones.
Lower highland zone	LH1-5	This zone comprises tea/dairy, wheat/maize-pyrethrum and lower highland ranching sub-zones.
Upper midland zone	UM1-5	This zone has coffee/tea, main coffee, marginal coffee, sunflower/maize, and livestock (including dairy) /sorghum sub-zones.
Lower midland zone	LM4-5	This is a livestock/millet zone. This zone has been excluded from the new district.

<u>Source</u>: Jaetzold and Schmidt (1983)

Figure 1: Map of Kenya showing the location of Kiambu district



Source: Central Bureau of Statistics (1993)

Source: Central Bureau of Statistics (1993)

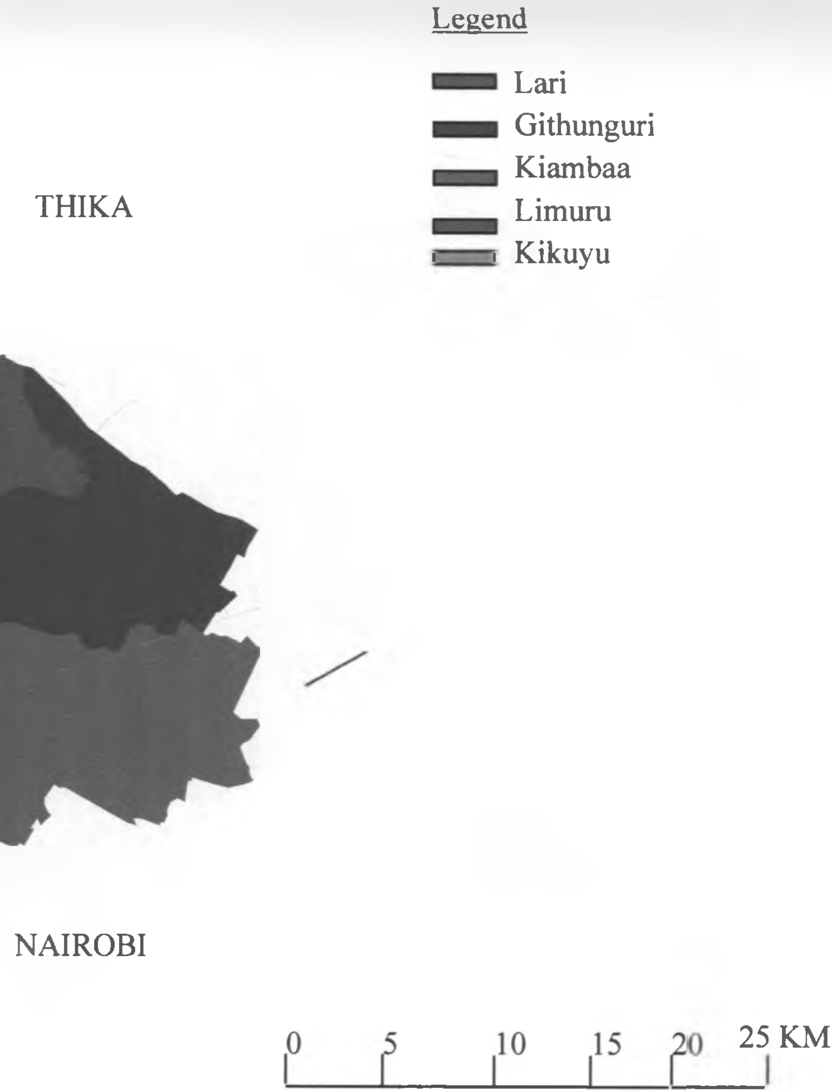
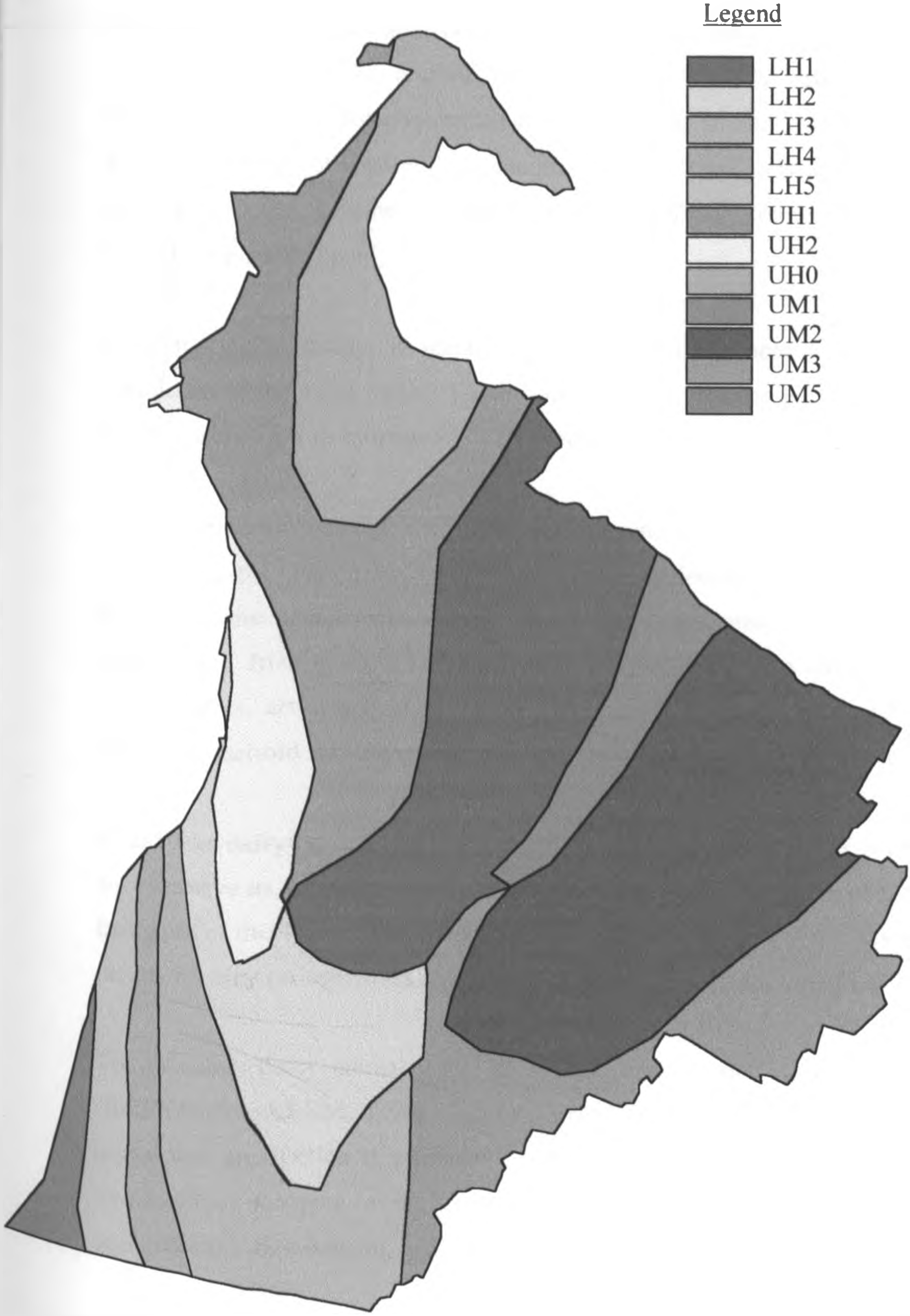

Legend
Lari
Githunguri
Kiambaa
Limuru
Kikuyu
THIKA
NAIROBI
0
5
10
15
20
25 KM

Figure 3: Map of new Kiambu district showing agro-ecological zones



Source: Jaetzold and Schmidt (1983)

1.6.2 Farming systems of Kiambu district

Kiambu is a high agricultural potential district with a land surface area of 258,700 hectares of which 142,200 is arable (Ombui *et al.*, 1996). The rest of the land ranges from low-to-medium potential meadows to rangeland around Ndeiya and Longonot. Two-thirds of the total arable land comprises small farms (less than five hectares in most cases) while the other one-third is made up of large farms (more than twenty hectares), which are mainly coffee or tea plantations.

Land in Kiambu district is mainly under individual freehold tenure, having been adjudicated in the early 1960s. Using a mean of six to seven persons per household, Kiambu district has an estimated 154,000 households.

Small-scale mixed farming is the main income generating activity in Kiambu district. The main cash crops grown are coffee and tea. Horticulture and floriculture are also practised in the wetter parts of the district. The major subsistence crops grown are maize, beans, Irish potatoes and vegetables. Minor subsistence crops grown include sweet potatoes, arrowroots and bananas. Although these crops are basically grown to meet the household subsistence needs, surplus is sold to supplement household income.

Smallholder dairying is a major activity in the district. The city of Nairobi and its environs serve as the major outlets for both fresh milk and other types of farm produce. Being part of the Nairobi milk-shed, milk from Kiambu district is directly delivered to the city by dairy co-operatives and itinerant milk traders (Owango *et al.*, 1997).

The estimated dairy animal population in Kiambu district is about 240,000 head (ILRI/KARI/MoALDM, 1996). About 60% of these animals are dairy cows whose annual milk production is estimated at 255 million litres. Other farming activities include poultry keeping for broiler meat and eggs, pig and beef production, and sheep, goat, rabbit and bee-keeping in the lower parts of the district (Inoti, 1994).

1.7 Organisation of this thesis

Chapter One of this thesis introduces the subject under investigation, i.e., the adoption of Napier grass in the smallholder dairying systems of Kiambu district. It outlines the development of smallholder dairying in Kenya, states the problem under investigation, the hypothesis tested and the objectives of the study. Also in this chapter the farming systems of the study area, Kiambu district, are briefly described.

Chapter Two of this work presents the literature review. Describing Napier grass as an agricultural technology in smallholder dairying, this chapter outlines the nature of adoption process, giving details of econometric methods used to analyse adoption decision. Thus Chapter Two lays a foundation for the formulation of the empirical model used to analyse the adoption decision in Chapter Three.

Chapter Four discusses results of data analyses while Chapter Five gives the conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter starts with some background information about Napier grass - its taxonomy, ecology and economic importance. Also in this chapter, the nature of adoption of agricultural technologies is discussed and details of the methods used to analyse the adoption decision presented to lay the foundation for the formulation of the empirical model in the next chapter. A survey of past adoption studies is briefly presented at the end of the chapter.

2.1.1 Napier grass - Taxonomy, ecological distribution and morphology

Napier grass is known by various names, such as Elephant grass (common name), "Mabua" (Kiswahili) and "Thaara" (Kikuyu). In botanical literature, it is referred to as *Pennisetum purpureum*. According to Boonman (1993), Napier grass thrives well in the Elephant grass zone (1,250-1,500M altitude). This zone has warm and humid conditions and is widely distributed in sub-Saharan Africa, stretching from Ethiopia to South Africa and from West Africa (along the rain forest belt) to East Africa. Outside the Elephant grass zone, Napier grass is restricted along the riverbeds. In Kenya, Napier grass is grown from zero to 2,500M above sea level (KARI-NDDP, 1992).

A mature Napier grass plant is five to six metres tall with up to 20 nodes per stem, though at times it grows outside this range. It has an underground woody rootstock consisting of short horizontal branched rhizomes. Growth is by aerial tillering from axial buds; leaf blades are either smooth or hairy. It rarely produces inflorescences, except under the most favourable conditions (Boonman, *op. cit.*), or when attacked by head smut (Lusweti *et al.*, 1997). It is usually evergreen and can be propagated either sexually or asexually, although the latter method is more successful. According to

Boonman (1993), eleven Napier grass clones (varieties) have been studied. Of these, Gold Coast ("Bana") is the most widely adopted variety in Kenya (Lowe *et al.*, 1996). This variety is widely grown in Kiambu, Kericho and Meru districts (Woulters, 1987).

2.1.2 Economic importance of Napier grass

The main uses of Napier grass include livestock feeding, soil conservation and mulching (especially in coffee plantations). Napier grass has also been used to provide building and fencing materials and in the manufacture of paper pulp in some east Asian countries (Boonman, *op. cit.*).

In the cut-and-carry livestock feeding system in the highland districts of Kenya, Napier grass is a major source of fodder. Its main strength for use as a fodder perhaps derives from its ability to withstand repeated cutting, coupled with rapid re-growth that produces high biomass which is very palatable in the leafy stage. Approximately 240,000 hectares of land, representing about 4% of the arable land in Kenya, were under Napier grass in 1983 (Lusweti *et al.*, *op. cit.*)[1]. The area planted with Napier may have increased since 1983 (Anindo and Potter, 1994) partly due to the fall in coffee prices (Lusweti *et al.*, *op. cit.*) and partly due to the increase in the number of farmers taking up dairying.

2.2 The nature of adoption of agricultural technologies

2.2.1 Definitions

Leagans (1979) defines "adoption" as the continued full use of an innovation. According to Rogers and Shoemaker (1971), an innovation is any new idea. Feder *et al.* (1985) argue that the definition of the term "adoption" should distinguish between farm-level adoption and aggregate adoption. Accordingly, farm-level adoption is defined as

[1] Napier grass is in most cases grown as a strip-crop with food crops such as maize and beans.

the degree of use of a new technology in the long-run equilibrium when the farmer has full information about the new technology and its potential; aggregate adoption is the level of use of a specific new technology within a given geographical area or population.

Famoriyo (1988) defines an agricultural technology as "all improved techniques, materials and tools used to achieve agricultural modernisation" (p. 515). Such technologies include agricultural machinery (e.g. ploughs, tractors and combines); high yielding varieties such as hybrid maize and Napier grass; chemical fertilisers and insecticides. In livestock production, modern technologies such as artificial insemination (AI), vaccines, veterinary drugs and feed formulations have been developed. The application of these technologies in the production process raises the technical efficiency of inputs to improve the input-output coefficients.

From a management viewpoint, Sellen *et al.* (1992) considered livestock production technology as the continuum that exists between extensive and intensive grazing. Their view was based on the degree of use of external purchased inputs and labour. Against this background, this study conceptualises three broad classes of "livestock production technologies" namely, extensive, semi-intensive and intensive grazing.

2.2.1.1 Extensive grazing system

The extensive grazing system is mainly found in the Kenya rangelands. These rangelands make up about three-quarters of the country and are distributed mainly in Nyanza, Rift Valley, North Eastern, Eastern and Coast Provinces. Apart from the Nyanza Province, the other provinces are inhabited by pastoralists who move herds of indigenous (*Bos indicus*) cattle from place to place in search of water and pasture. Cattle herd sizes are usually considerably large. Livestock are mainly kept for subsistence purposes. Very little purchased inputs are used; the most common being curative drugs for the treatment of tick-borne diseases (especially East Coast Fever) and trypanosomosis. Modern disease control measures like vaccination against rinderpest and contagious bovine pleuro-pneumonia (CBPP) are rarely practised, unless they are provided by the Government (Irungu, 1999). Family labour is used almost exclusively (Sellen *et al.*, 1992).

Under this system of grazing, cows are generally milked for the first 3-5 months of lactation. Annual milk yield is low at about 200 litres. Calves are weaned at 5-7 months *post partum*. Pre-weaning calf mortality is about 20% p.a., usually due to tick-borne diseases and malnutrition (MoALDM/KARI/ILRI, 1998).

The average feed and labour requirements are about 3,700 kg of forage matter and 330 hours per cow per year respectively (Nyangito, 1992). The average calving interval is about 18 months. Most of the heifers are underdeveloped due to poor nutrition and usually calf-down for the first time when they are about four years old. The average gross margin is estimated at KShs 7,000 per year per cow (MoALDM/KARI/ILRI, 1998).

2.2.1.2 Semi-intensive grazing system

This system of grazing is found in the high potential areas of Kenya with medium-size land holdings of up to 10 hectares (MoALDM/KARI/ILRI, 1998). Semi-intensive grazing is mostly practised in parts of Central, Eastern, Western and Rift Valley Provinces (Sellen *et al.*, 1992). Farmers keep exotic cattle breeds (*Bos taurus*) and their crosses. Grazing on natural pastures is usually supplemented with cultivated fodder in a cut-and-carry system of feeding. Due to this practice, the system is usually referred to as 'semi-zero' grazing system. Purchased inputs such as manufactured feeds, hired labour, veterinary and AI services are widely employed in the production process.

The mean annual milk yield is about 1,500 litres per cow. The average calving interval varies between 12 and 16 months while pre-weaning calf mortality is about 15% per year (MoALDM/KARI/ILRI, 1998). The mean annual animal feed and labour requirements are about 6,300 kg of forage matter and 460 hours per cow per year. The average gross margin from this system is estimated at KShs 20,000 per cow per year (MoALDM/KARI/ILRI, 1998).

2.2.1.3 Intensive grazing system

This system is commonly called zero grazing. According to de Jong (1996), the zero grazing package was developed in Kenya to solve the constraints of land scarcity and to improve on milk production and cattle reproduction through the introduction of cubicle housing for cattle, improved fodder (Napier grass) and recycling of manure (p. 58). Here, exotic (*Bos taurus*) breeds and their crosses are kept under intensive grazing mainly for commercial dairy purposes. The system is mainly concentrated in Central Province, central Rift Valley and the Coastal lowlands where land holdings average four hectares per household (Peeler and Omore, 1997). As a result, animals are confined in one place where they are stall fed (zero grazed) with fodder cut from the field. Napier grass is the main source of dry matter. Crop residues and grass clippings from roadside reserves are also used to supplement Napier. Manufactured feeds such as wheat bran and dairy meal are widely used especially at milking. Veterinary and AI services are more widely used here than in the semi-zero grazing system. As a result, annual milk offtake is relatively high averaging around 2,000 litres per cow. Calving interval is about 14 months (Nyangito, 1992). Male calves are normally sold 2-3 weeks *post partum*. Female calves are usually bucket-fed and are either sold or retained in the herd as replacement heifers. Pre-weaning calf mortality is about 10% per annum in well-managed farms. On average, about 730 hours of labour (van der Valk, 1990), and 7,200 kg of forage matter are required per cow per year (Nyangito, 1992). The average gross margin per cow is higher than in the other two systems and is estimated at about KShs 25,000 per year (MoALDM/KARI/ILRI, 1998).

The zero grazing system has several advantages over other grazing systems: one, and perhaps the most important, is that it offers a regular income throughout the year; the output per hectare compares favourably with that from cash crops (Maarse *et al.*, 1998). It also has a better utilisation of fodder, increased milk output, better manure management, intensive land use, low risk of infection by tick-borne diseases, and protection of animals against theft. Because the animals do not walk in search for fodder as in the other two grazing systems, more of their energy is available for production. The main disadvantage of the zero grazing system is that it involves high investment costs. According to Staal *et al.* (1997), much of the dairy production in Kiambu district, the focus of this study, is under intensive (zero) grazing system where Napier grass is the main fodder. Table 2.1 below summarises the characteristics of the main cattle production systems in Kenya discussed above.

Table 2.1: Characteristics of the main cattle production systems of Kenya

Production parameter	Extensive grazing	Semi-intensive grazing	Intensive grazing
Grazing management	Open grazing	Semi-zero grazing	Zero grazing
Land size (ha)	Communal	10	4
Cattle breeds	Zebu	Exotic/Crosses	Exotic/Crosses
Planted pasture (ha)	0	<1	1
Herd size	>30	1-20	1-10
Proportion of breeding cows (%)	35	40	40
Breeding management	Bull	Bull/AI	Bull/AI
Age at first calving (yrs)	4	3	3
Calving interval (months)	18	12-16	14
Lactation length (days)	<200	450	450
Pre-weaning calf mortality (%) p.a.	25	15	10
Labour requirements (hrs/cow/yr)	330	460	730
Forage requirements (kgs of forage matter/cow/yr)	3,700	6,300	7,200
Milk offtake (lts/cow/yr)	200	1,555	2,000
Milk for calf rearing (lts/cow)	Suckling	270 (bucket)	270 (bucket)
On-farm consumption (lts/cow/yr)	150	650	650
Cull cows sold annually	1	0.29	0.29
Bull calves sold annually	2.7	0.68	0.79
Heifer calves sold annually	1.7	0.39	0.51
Average gross margin (KShs/cow/yr)	7,000	20,000	25,000

__Source__: Stotz (1983); van der Valk (1990); Sellen *et al.* (1992); Nyangito (1992); MoALDM/KARI/ILRI (1998)

2.2.2 Conceptualising adoption behaviour

The process of adoption is an expression of reasoned behavioural tendencies and can be explained by socio-psychological principles of human behaviour. Leagans (1979) indicates that the process of adoption is triggered by influences both external and internal to the potential adopter. The external influences determine the complexity of the decision problem to be solved while internal influences determine the adopter's competence in decoding relationships between his behaviour and the environment (Heiner, 1983).

Viewing the two influences as two broad classes of adoption-behaviour influencing variables, Heiner (*op. cit.*) argues that they determine the size of the gap between the ability of the individual to decode information and the environmental difficulty. This gap produces uncertainty about how to use available information in selecting potential actions. The uncertainty arises from cognitive limitations either in processing given information or in interpreting potential information from the environment. In addition, uncertainty may also arise from the inability to infer from past experience (Heiner, *op. cit.*).

The two influences described above are articulated in the mind of the adopting agent as perceived reasons for (incentives[1]) or against (disincentives[2]) an innovation. Consequently, the process of adoption begins when a potential adopter feels that the incentives outweigh the disincentives. This essentially implies a 'benefit-cost analysis' playing in the mind of the potential adopter to the effect that if the perceived discounted marginal benefits of the adoption process are greater than the perceived discounted marginal costs, the potential adopter adopts the technology (Leagans, 1979).

---

[1] An incentive is any condition or reason that motivates a farmer to begin to use a recommended group of farm practices (Leagans, 1979).

[2] A disincentive is any condition or reason that inhibits a farmer from beginning to use a recommended group of farm practices (Leagans, 1979).

2.2.3 Models used to explain adoption behaviour

Adesina and Zinnah (1993) report two models which have been used to explain adoption behaviour. These are the innovation-diffusion and economic constraint paradigms. The innovation-diffusion model emphasises on the need to have information about the technology available to potential adopters while the economic constraint model focuses on the level of resource endowment at the disposal of adopting agents.

Whereas both focus on factors external to the decision maker, the final adoption decision depends, to a large extent, on the state of mind of the decision maker at the time of making that decision. Therefore, when formulating adoption models, it is important to integrate factors both external and internal to the decision making unit. It is on this basis that Kivlin and Fliegel (1966) formulated the adopter perception model. This paradigm postulates that individual perceptions about the attributes of the innovation condition adoption behaviour. This arises from the fact that the value of the innovation to the adopting agent is manifested only when that innovation serves the need(s) for which it was created. Therefore, a potential adopter may fail to adopt a particular innovation if its attributes differ with his/her expectations. This study uses the economic constraint paradigm to evaluate the factors that influence farmers' decision to adopt Napier grass in smallholder dairying in Kiambu district.

2.3 Modelling adoption behaviour[1] in econometrics

From the foregoing, the adoption decision is a behavioural response arising from a set of alternatives and constraints facing the decision maker. These alternatives and constraints are weighed against each other in the mind of the adopter to bring about the observed choice - which is either or not to adopt the technology. Conceptually, the decision can be related to the set of alternatives and constraints facing the decision

[1] There are two general types of models to analyse adoption behaviour depending on whether the adoption process is farm-level or aggregate. Since this study focuses on individual farmers, only the farm-level adoption models are reviewed.

maker as in the following hypothetical model:

Decision = f(alternatives, constraints); (2.1)

subject to: desired welfare criterion (e.g. a higher utility).

Equation (2.1) relates the adoption decision to the set of constraints and alternatives available to the decision maker at the time of making that decision.

2.3.1 Discrete choice models

Mathematically, equation (2.1) can be expressed in the following regression:

$$y_i = \beta'\mathbf{x}_i + \varepsilon_i \qquad (2.2)$$

where y_i is the decision of the ith individual, β is a column vector of unknown parameters, $\mathbf{x}$ is a matrix of known variables, while ε is a stochastic disturbance term. The individual either adopts (y_i='Yes') or rejects (y_i='No') the technology. It is common practice in econometrics to equate the 'Yes' decision with 1 and the 'No' decision with 0 (Judge *et al.*, 1988). Under this formulation, equation (2.2) becomes a discrete choice (or qualitative response) model whose dependent variable, y_i, is either zero or one denoting, respectively, that the ith individual has rejected or accepted the technology in question. The probability that individual i will adopt a particular technology is given by:

$$\text{Prob}\ (y_i=1) = F(\beta'\mathbf{x}), \qquad (2.3)$$
$$\text{Prob}\ (y_i=0) = 1-F(\beta'\mathbf{x}).$$

β in equation (2.3) is estimated by use of maximum likelihood techniques. The maximum likelihood estimation predicts the likelihood that a given data sample comes from a population with a particular set of parameter values. Thus, the maximum likelihood estimate (MLE) of a vector of parameter values β is the particular vector

β^{MLE} which gives the greatest probability of obtaining the observed data (Kennedy, 1985). The maximum likelihood estimates are found by maximising the likelihood function with respect to the parameters.

2.3.2 Limited dependent variable models

There are cases in economics where the dependent variable is only observed in some range. Such cases are common in adoption surveys where, for example, only some of the respondents adopt a particular technology while the others do not. In such a case, the researcher may, depending on the type of technology under investigation, observe varying degrees of adoption among adopters but no adoption at all among non-adopters even-though, intrinsically, they may be at differing states of non-adoption, just like in the case of the adopters.

To illustrate this point, suppose in an adoption survey data indicate that maize farmers in a certain locality use fertiliser while others do not. From the data, the adopting farmers apply different amounts of fertiliser per hectare of maize, say, from 10 to 100kgs. All non-adopters are lumped together as 'applying' zero kg of fertiliser per hectare despite the fact that they may be at differing states of non-adoption (e.g. some may require just a little persuasion to start using fertiliser while others may never use fertiliser at all). Considering the entire data set, one can separate the non-adopters from the adopters. This essentially constitutes separating the zero from the non-zero observations. Among the adopters, there are differences in the amount of fertiliser used per hectare. Equally likely is the fact that non-adopters may be at different levels of non-adoption. Thus, the dependent variable (in this case the quantity of fertiliser used per hectare of maize) is censored about zero in the sense that it is only observable for non-negative quantities.

Relating the censored dependent variable in the above example to the set of variables that are likely to influence it gives a limited dependent variable model. This model has two parts: the first part involves the decision of whether or not to adopt the technology.

This part constitutes a qualitative response model with a discrete (0/1) dependent variable. It is analysed by use of either probit or logit models (details discussed below).

The second part of the limited dependent variable model involves deciding how much of the technology to use once the decision to adopt has been made. It comprises the non-zero observations. It is likely that this decision is/will be influenced by a set of factors different from those influencing the adoption decision. Relating these variables in a regression equation gives rise to a continuous dependent variable model. This sort of model cannot be adequately analysed by use of ordinary least squares (OLS) estimation because the range of the regressand is inherently bounded and there is a concentration of the regressand at its bound (Goldberger, 1964). Thus, the resulting OLS estimates are biased and inconsistent because the disturbance term is not independent of the explanatory variables (Mbata, 1997). Judge *et al.* (1988) indicate that the bias that results from using least squares to fit models with the limited dependent variables with censoring arises because the conditional mean of the disturbance term is not included as a separate regressor in the regression model. Further, the disturbance term is not normally distributed and therefore the classical statistical tests are not applicable. Under these circumstances, the tobit model (see below) becomes more appropriate. The tobit model provides an estimate of the probability that a specified farmer will be an adopter and, for the adopters, the level of use of the technology adopted.

2.3.3.1 The probit model

In this model, the error term, ε, is assumed to have a normal distribution (Maddala, 1983). Thus, the probability that an individual will adopt a particular technology is given by integrating the area under the normal density curve to get a cumulative distribution function:

$$\text{Prob}\,(y=1) = \int_{-\infty}^{\beta' x} \phi(t)\,dt$$

$$= \Phi(\beta'\mathbf{x}) \qquad (2.4)$$

where $\phi(.)$ and $\Phi(.)$ are the notations for the normal density and cumulative standard normal distribution functions respectively.

2.3.3.2 The logit model

In the logit model, ε is assumed to have a logistic distribution (Maddala, 1983). According to Greene (1993), the density function of the logit model is defined as:

$$\text{Prob}\ (y=1) = \frac{e^{\beta' x}}{1+e^{\beta' x}} \qquad (2.5)$$

$$= \Lambda(\beta'\mathbf{x})$$

where e is the natural logarithm base and $\Lambda(.)$ is the notation for the logistic cumulative distribution function.

The advantage of probit and logit models is that the probabilities are bound between 0 and 1. Moreover, they compel the disturbance terms to be homoscedastic because the forms of probability functions depend on the distribution of the difference between the error terms associated with one particular choice and another. Usually a choice has to be made between logit and probit, but as Amemiya (1981) observed, the statistical similarities between the logit and probit models make such a choice difficult. Choice of any model is therefore not dominant and may be evaluated *a posteriori* on statistical grounds, although in practice even here there are no strong reasons for choosing one model over the other (Ntege *et al.*, 1997). The probit model was used in this study because it is one of the steps in the set up of the tobit model suggested by Goetz (1995).

2.3.3.3 The tobit[1] model

The tobit model is a maximum likelihood method whose dependent variable, y_i, is fixed at either an upper or a lower limit (Amemiya, 1985; Tobin, 1958). Depending on the nature of the data, tobit models are either censored or truncated. A censored regression (usually called tobit model) is one for which some of the y_i observations are missing but for which all the $\mathbf{x}_i$ observations are present. In the truncated model, observations on y_i and the corresponding $\mathbf{x}_i$ are entirely missing if y_i is below or above a certain threshold level (Maddala, 1983). Greene (1993) distinguishes the two models as follows:

(a) The truncated model

Given the model in equation (2.2), i.e.,

$$y_i = \beta'\mathbf{x}_i + \varepsilon_i, \qquad (2.6)$$

and assuming that a general mean, μ, is equal to $\beta'\mathbf{x}_i$ and that ε is approximately normally distributed with mean zero and a common variance σ^2, the regression of y_i on $\mathbf{x}_i$ is approximately normally distributed with mean $\beta'\mathbf{x}_i$ and variance σ^2 (Greene, 1993). i.e.,

$$y_i|\mathbf{x}_i \sim N[\beta'\mathbf{x}_i, \sigma^2]. \qquad (2.7)$$

If the truncation point for y_i is a constant a, then the distribution of y_i given that y_i is greater than the truncation point is given by Greene (1993) as:

$$E[y_i|y_i > a] = \beta' x_i + \sigma \frac{\phi(a - \beta' x_i)/\sigma)}{1 - \Phi(a - \beta' x_i)/\sigma} \qquad (2.8)$$

---

[1] The term "tobit" was coined by Goldberger (1964) to describe Tobin's (1958) hybrid model of probit and multiple regression models, then called Tobin's probit. Since Tobin's time, a large variety of tobit models has evolved. Amemiya (1985) categorises tobit models into five basic classes, depending on the form of the likelihood function that they take. See Amemiya (1985): p. 361-411, for details.

where σ is the standard deviation, ϕ and Φ defined as above are evaluated at $\beta'\mathbf{x}_i/\sigma$. Equation (2.8) is a truncated model which relates y_i to $\mathbf{x}_i$ in a non-linear fashion.

(b) The censored regression model

According to Greene (1993), the general formulation of the censored regression is an index function shown below:

$$\begin{aligned} y_i^* &= \beta'\mathbf{x}_i + \varepsilon_i, & & \\ y_i &= y_i^* & \text{if } & y_i^* > 0, \\ y_i &= 0 & \text{if } & y_i^* \leq 0 \end{aligned} \tag{2.9}$$

where the index variable, y_i^*, defines an underlying unobservable tendency. β, $\mathbf{x}_i$ and ε_i are as previously defined. In equation system (2.9), the mean of y_i^* is $\beta'\mathbf{x}_i$. For convenience, the censoring point for the model is usually assumed to be zero (Greene, 1993). The censored regression model utilises both limit (y_i=0) and non-limit (y_i>0) observations to estimate β and σ^2 (see Maddala (1983) for details). Thus, a censored regression consists of a mixture of discrete and continuous parts (Greene, 1993).

In economics, it is the marginal rather than the total effect of a factor or activity on the entire economy which is more relevant when gauging the outcome of an intended change. Tobit models have a provision for evaluating the effects of a change in $\mathbf{x}_i$ on the expectation of y_i. This is achieved by partially differentiating the model with respect to the factor of importance. For the truncated model (2.8) above, the marginal effects are obtained by differentiating the expectation of y_i being above the truncation point a:

$$\partial E[y_i|y_i>a]/\partial\mathbf{x}_i = \beta + \sigma(d\lambda_i/d\alpha_i)(\partial\alpha_i/\partial\mathbf{x}_i) \tag{2.10}$$

where $\alpha_i = (a - \beta'\mathbf{x}_i)/\sigma$ and $\lambda_i = \phi(\alpha_i)/(1 - \Phi(\alpha_i))$.

Unlike in the truncated model, the marginal effects of the censored regression are obtained by differentiating the expectation of the index variable y_i^* on $\mathbf{x}_i$ as follows:

$$\partial E[y_i^* | \mathbf{x}_i] / \partial \mathbf{x}_i = \beta \qquad (2.11)$$

The marginal effects of the censored regression can further be disaggregated into two parts following the method of McDonald and Moffitt (1980):

(i) the change in E[y] of those observations above the limit, weighted by the probability of being above the limit; and

(ii) the change in the probability of being above the limit, weighted by the expected value of y if above the limit. This gives the effect of change of $\mathbf{x}_i$ on the probability of the expected level of use of the technology among the adopters and effect of change of $\mathbf{x}_i$ on the probability of being an adopter.

2.4 Past studies that have used tobit models

Since Tobin's (1958) pioneering study on the American households expenditure on durable goods, several studies have used the tobit model to analyse farmers' technology adoption decisions. For instance, Shapiro *et al.* (1992) used the tobit model to determine factors that influence the adoption of double-crop soybeans and wheat by farmers of the mid-west USA. Their empirical model incorporated profit and farmer's risk perception. From the estimated tobit model, risk perception about the double-cropping technology was significant in explaining the mid-west USA farmers' adoption behaviour. This observation contrasted previous findings that had found the adoption decision to be only influenced by the farmer's level of formal education and farming experience.

Adesina and Zinnah (1993) applied the tobit model to test the role of farmers' perceptions in technology adoption decisions. Their study was conducted on a sample of mangrove swamp rice farmers in Sierra Leone. The results showed that farmers' perceptions of the technology-specific attributes were the major determinants of the probability of adoption as well as use intensity of different rice varieties.

Other studies (besides adoption) which have used the tobit model include those by Shapiro and Brorsen (1988) and Tambi (1994). Shapiro and Brorsen used the tobit model to analyse factors that affect hedging decisions of a sample of Indiana corn and soybean farmers. They found farmers' perception of the ability of the futures markets to reduce risk and farmers' debt position to be the most important factors explaining farmers' decision to participate in the futures markets.

Tambi (1994) applied a tobit model based on Heckman's (1978) procedure to analyse the urban demand for fish and livestock products in Cameroon. He found all own-price elasticities for beef, chicken, pork, eggs and fish to be statistically significant but less than unity in absolute terms. Income was found to significantly affect the demand for all the products studied except pork.

Recently, Nkonya *et al.* (1997) applied a tobit model to evaluate factors affecting the simultaneous decision of adoption of improved maize seed and fertiliser in northern Tanzania. The results indicated that the adoption of improved maize seed was positively affected by the quantity of nitrogen used per hectare, farm size, farmer's level of education and visits by extension agents. The probability of adoption of commercial fertilisers, on the other hand, was positively related to the area planted with improved seed. In general, their results demonstrated the importance of human capital factors in farmers' technology adoption decisions.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the methods of data collection and analysis used in the study. It also gives the conceptual framework upon which the empirical model is developed.

3.2 Data collection

This study used primary data collected in two phases. Both phases involved questionnaire interviews with farmers from Kiambu district. Phase I data were gathered by ILRI's Market-Oriented Smallholder Dairy Research (MOSD) team, the Ministry of Agriculture Livestock Development and Marketing (MoALDM) and the Kenya Agricultural Research Institute (KARI) between June and July 1996. The aim of the data collection exercise was to carry out a broad-based characterisation of the dairy system in Kiambu district. These data were used in this study to test the hypothesis that the decision to adopt Napier grass and the level of adoption of Napier grass is influenced by farmer's household and resource attributes as well as market and institutional factors.

Phase II data were collected in July 1997 by the author in a mini survey of 30 households. This phase was a follow-up to the 1996 dairy characterisation study, hereafter referred to as the MoALDM/KARI/ILRI survey. The author's survey assessed farmers' perceptions of the factors that influence their decision to adopt Napier grass. In addition, a simple partial budget showing the trade-off between growing Napier grass and maize stover, two of the most widely used fodders in the district, was calculated.

The questionnaire for the MoALDM/KARI/ILRI survey covered topics on household, farm and livestock characteristics. In the author's survey, the questionnaire gathered information pertaining to changes in these characteristics since the 1996 visit, Napier and maize production practices, as well as confirming the significance of some of the variables in the empirical model (see Appendix I).

3.3 Sample selection

3.3.1 The MoALDM/KARI/ILRI survey

Based on the agro-ecological zones described in Jaetzold and Schmidt (1983), eight sub-locations were randomly selected from each of the three major land-use systems in Kiambu district. These land-use systems were tea/dairy (agro-ecological zones UH1 and LH1), coffee/dairy (UM1 and UM2), and horticulture/dairy (UH2, UM3, LH2, LH3 and LH4-5) (see Table 1.1). Twenty-four of the 99 sub-locations were sampled (see Appendix II). One per cent of the total number of households in each sub-location was interviewed between June and July 1996. The total number of households in a sub-location was obtained from the 1989 census figures (CBS, 1993). Eventually, a sample of 365 households was considered an adequate representation for households in Kiambu district.

Sub-location maps were made using computer graphic systems. The enumerators (front-line extension staff from MoALDM) were required to mark the main landmarks[1] in the study area on the maps. Line transects were then drawn joining the landmarks and sampling was done along the transects. Due to the high concentration of households in the study area, interviews were conducted in every fifth household on the right and on the left alternately.

[1] A landmark was defined as any permanent feature like a trading centre, a school, a church, or a factory.

3.3.2 The author's survey

Purposive sampling[1] was done on the 1996 survey data to select households with Napier and dairy; households with Napier and no dairy, and households with dairy and no Napier. Households with peculiar characteristics - such as unusually large fodder purchases and little or no fodder purchases despite having little or no planted fodder - were given priority. A sample of 30 households was selected.

The questionnaire was pre-tested two weeks prior to the actual survey and adjustments made. Interviews were conducted using the local dialect (Kikuyu) by the author assisted by the Acting District Livestock Extension Co-ordinator. Front-line extension staff from MoALDM helped the author to identify the households to be interviewed following the layout of the main survey. In both surveys the household head was the basic unit of interview. Where the household head was absent, an adult household member familiar with farm operations was interviewed instead.

3.4 Data processing and analysis

The gathered data were entered into the computer and descriptive statistics determined for each data set. Data from the author's survey were used to derive the partial budget while those from the MoALDM/KARI/ILRI survey were used for hypothesis testing in the econometric analysis.

3.5 Theoretical framework

The adoption decision is a behavioural response arising from a set of alternatives and constraints facing the decision-maker (Sections 2.2.2 and 2.2.3). The set of factors that

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[1] Purposive sampling is done where the researcher is looking for a sample with peculiar characteristics (Konijn, 1973).

influence technology choice can be broadly categorised into four major groups of attributes, namely, technology attributes (its price, applicability, and productive potential), resource attributes (level of land, labour and capital), institutional attributes (production and marketing policies and access to information), and farmer's attributes (tastes and preferences and information processing capacity).

Defining i = individual (i.e. the decision making unit, such as farmer, household, etc), y = technology choice, x_k = type (k) of attribute and U = expected utility, then, the technology choice of the ith individual is a function of the set of attributes, i.e.,

$$y_i = y_i(x_k). \tag{3.1.1}$$

If farmers were conceptualised as consumers of agricultural technology, then the random utility theorem postulates that they will choose that technology from whose application they expect the highest utility (Batz *et al.*, 1997; Adesina and Zinnah, 1993; Strauss *et al.*, 1991; Kebede *et al.*, 1990; Kennedy, 1985; Rahm and Huffman, 1984). This utility is a function of the characteristics of the individual and the attributes of the technology, i.e.,

$$U_{iv} = U_{iv}(y_i, y_i(x_k)). \tag{3.1.2}$$

Eventually, the individual will be seeking to maximise utility from technology choice y:

$$\text{Max } U_{iv} = U_{iv}(y_i, y_i(x_k), \varepsilon_{iv}) \tag{3.1.3}$$

subject to his/her objective function and resource constraints.

3.5.1 Theoretical model

Since adoption is a choice rather than a technical outcome, the level of inclination to adopt cannot be observed until it results in adoption. Thus, the adoption decision is an underlying latent tendency which can be formulated as an unobserved index variable, y_i^*, such that adoption is only observed when y_i^* is above a certain threshold level. Taking this threshold to be zero and transforming y_i in equation (3.1.1) into y_i^*, then y_i^* can be expressed as a function of $\mathbf{x}_i$ in the following regression:

$$
\begin{aligned}
& y_i^* = \beta'\mathbf{x}_i + \varepsilon_i, \\
& y_i = y_i^* \quad \text{if} \quad y_i^* > 0 \\
& y_i = 0 \quad \text{if} \quad y_i^* \leq 0.
\end{aligned} \qquad (3.2)
$$

β is a vector of unknown parameters. Equation (3.2) means that adoption (y_i) will be observed only when the latent tendency is above the unobservable threshold ($y_i^* > 0$). To estimate the probability of adoption, equation (3.2) is analysed using either probit or logit models. Where it is important to estimate the level of adoption as well, the tobit model is applied on equation (3.2).

3.5.2 Choice of analytical models

Data from the MoALDM/KARI/ILRI survey indicated that 30% of the 340 agricultural farmers did not grow Napier grass while the ones who did so grew it on land sizes varying between 0.2 and 1.2 hectares. This gave a data set with a mixture of censored (30%) and uncensored (70%) observations. In econometric studies, data sets with censored and uncensored observations do not lend themselves to be properly analysed by ordinary least squares (OLS) procedure because OLS fails to utilise the censored observations. Thus, the resulting OLS parameter estimates are biased and inconsistent (see Section 2.3.2). In this study, the censored observations were analysed using the probit model while the tobit model was employed to analyse both censored and uncensored observations.

3.6 Empirical model

The formation of the empirical model was influenced by a number of working hypotheses. It was hypothesised that a farmer's decision to adopt or reject new agricultural technologies at any one time is influenced by the combined effect of a number of factors related to the farmer's objectives and constraints. Considering Napier grass as the y_i^* technology choice in equation (3.2) above, the following empirical model was fitted into the MoALDM/KARI/ILRI survey data:

$$\begin{aligned} NAPLAND_i = \; & \beta_0 + \beta_1 EDUC + \beta_2 YRSEXP + \beta_3 GENDER + \beta_4 BREED + \\ & \beta_5 ZON1 + \beta_6 ZON2 + \beta_7 TOTLAND + \beta_8 FAMLAB + \\ & \beta_9 OFFARM + \beta_{10} TLUCAT + \beta_{11} MLKPRICE + \beta_{12} FORPUR + \\ & \beta_{13} COOPMEMB \; \beta_{14} EXTADV + \beta_{15} TOTETVST + \varepsilon_i \\ \text{if} \quad & NAPLAND_i > 0 \end{aligned}$$

$$NAPLAND_i = 0 \quad \text{if} \quad NAPLAND_i < 0 \qquad (3.3)$$

The dependent variable, $NAPLAND_i$, is the area (in hectares) under Napier grass for the ith household at the time of the survey.

The next section describes the set of independent variables that were hypothesised to influence farmers' decision to adopt Napier grass in smallholder dairying in Kiambu district. The independent variables were categorised into four classes in accordance with the stated hypotheses of this study (see Section 1.5). In this study, the household head was assumed to be the main decision maker for the household on matters pertaining to farming in general and land allocation in particular. This assumption arose from the fact that for a majority of ethnic groups in Kenya the household head (whether male or female) is usually the custodian as well as the manager of household property (Mbithi, 1974). Ruthenberg (1985, p.12) indicates that "it appears an acceptable simplification to treat the 'farmer' as an individual manager making decisions on behalf of his family. It is then hypothesised that the farmer's decision-making principally relates to meeting his and his family's subsistence requirements, to striking a balance between labour and leisure, to choosing between consumption and saving, and to coping with risk and uncertainty". This study adopts Ruthenberg's view.

(a) Farmer's household characteristics

The farmer's household characteristics hypothesised to influence the adoption decision were:

EDUC: Number of years of formal schooling for the household head. EDUC was coded from the categorical variable in the questionnaire into a continuous variable (Table 3.1) to facilitate the derivation of the marginal effects in the empirical model.

Table 3.1: Coding for household head's level of education

Questionnaire coding (discrete variable)	Coded continuous variable (years)
0=No formal education	0
1=Primary school level	7
2=Secondary school ('O' level)	11
3=Post secondary ('A' level)	13
4=Technical college (e.g. Agriculture college)	16
5=Adult literacy	7
6=Others	7

Shapiro and Brorsen (1988) and Gould *et al.* (1989) noted that the level of education attained influences both the rate of adoption and the adoption behaviour of the decision-maker. This is because education tends to reduce farmers' risk aversion thus enabling them to try out new innovations (Welch, 1979). Besides, farmers who are well educated acquire enhanced information processing capabilities that enable them to demand for and utilise complex agricultural technologies. By so doing, their technical and allocative efficiency is improved (Strauss *et al.*, 1991; Ntege *et al.*, 1997). In this study, the number of years of formal education of the household head was hypothesised to be positively related to both the probability and the level of adoption of Napier technology.

YRSEXP: Years of farming experience of the household head. This is a continuous variable computed as the total number of years that a household head had farmed up to the time of the survey. This variable was also used to proxy for the age of the household head as it is highly correlated with age.

Frank (1995) observed that individuals assess the utility of new practices by relating their perception of the practice to their experience and interpreting the value of that practice to their needs. If that experience suggests that the potential rewards to be gained from an adoption process will be greater than expected efforts or costs, the individual is likely to adopt the innovation (Rogers, 1962). In this study, the household head's farming experience was hypothesised to be positively related to the probability and the level of adoption of Napier grass. This is because, with time, dairy farmers are not only better able to assess the feed requirements of their animals, but are also able to allocate their land more effectively amongst competing enterprises.

GENDER: This variable was coded as a dummy, δ_1, representing the sex of the household head; $\delta_1=1$ for male household heads and $\delta_1=0$ for female household heads. Among the Kikuyu community that inhabits Kiambu district, land is customarily inherited from father to son. Thus, the male-headed households are expected to own more land than female-headed households. Generally, farmers with big land sizes are expected not to readily adopt the Napier technology because to them land is not a constraint; they can use some of the land as grazing pastures (see below). It was therefore hypothesised that GENDER would be negatively related to the probability of adoption as well as the level of adoption of Napier technology in Kiambu district.

BREED: Breed of cattle kept by the household. This variable was coded as a dummy, δ_2. $\delta_2=1$ if the household kept exotic dairy cattle and $\delta_2=0$ if the household kept indigenous cattle. Studies indicate that exotic dairy cattle have higher feed requirements than indigenous cattle (Nyangito, 1992; also see Section 2.2). Accordingly, farmers who kept exotic breeds were expected to adopt high biomass yielding fodders such as Napier grass in order to meet the feed requirements of their cattle to ensure productivity. It was therefore hypothesised that BREED would be positively related to both the probability and level of adoption of Napier grass among the smallholder farmers in Kiambu district.

ZONE (ZON1, ZON2, ZON3): The land-use zone to which the farmer belonged. According to Nicholson *et al.* (1998), household location may affect the appropriateness of the technology through the influences of climate, and access to markets for the inputs and outputs related to the technology. This study was conducted in three land-use zones, namely, horticulture/dairy, coffee/dairy and tea/dairy. Accordingly, three dummy variables, ZON1, ZON2 and ZON3, representing horticulture/dairy, coffee/dairy and tea/dairy, respectively, were used capture the effect of the physical environment (e.g. soil, temperature and rainfall) on the probability and the level of adoption of the Napier technology by the sample farmers. $\delta_3=1$ if a household was located in the horticulture/dairy zone and $\delta_3=0$ otherwise, $\delta_4=1$ if a household was located in the coffee/dairy zone and $\delta_4=0$ otherwise, and $\delta_5=1$ if a household was located in the tea/dairy zone and $\delta_5=0$ otherwise. ZON3 was dropped from the equation to avoid the 'dummy variable trap'. It was expected that the better the physical environment of the farm the greater the likelihood of adoption of the Napier technology. Feder *et al.* (1985) argue that a more favourable physical environment increases the expected utility of income from modern production. This increases the probability that a farmer will adopt the new technology. Thus, both ZON1 and ZON2 were hypothesised to be positively related to both the probability and the level of adoption of Napier.

(b) Farmer's resource attributes

This group of variables comprises the three major factors of production in neo-classical economics, namely, land, labour and capital. Off-farm income and number of cattle owned were considered to be indicators of wealth or capital.

TOTLAND: Total land size owned by the household (in hectares). TOTLAND is a continuous variable.

According to Ntege *et al.* (1997), farm size is an indicator of wealth, social status as well as influence within a community. Norris and Batie (1987) found farm size to be positively related to farmers' adoption decisions. In general, farmers with big pieces of land have more flexibility in their land allocation decision compared to those with small land sizes. Owing to the small land holdings in Kiambu district, one would expect that farmers with small land sizes would readily adopt the Napier technology as one way to overcome the land constraint. However, the level of adoption of Napier, as measured by area allocated to Napier grass, would be lower. It was therefore hypothesised that the probability of adoption of Napier would decrease with increase in land size while the level of adoption of Napier would increase with increase in land size for the adopters if they still considered it profitable to do so.

FAMLAB: Quantity of family labour available to the household for farming purposes. This variable was measured in adult equivalents. An adult (over 21 years) was assigned one adult equivalent while the youth (15-21 years), were assigned one-half as much because they were expected to be in school most of the times. As such, FAMLAB is a continuous variable.

The production and processing of Napier grass are labour intensive farm operations. Therefore, farm families were expected to have adequate labour if they are going to produce enough quantity of Napier grass. Due to constraints of cash as a result of inadequate productive resources, smallholder farmers have a low propensity to hire labour outside their farms. They mainly use family labour to do most of the farming operations. In this study the quantity of family labour available in a household for farming purposes was hypothesised to be positively related to both the decision and the level of adoption of Napier grass.

OFFARM: Whether or not the household head had off-farm employment. This variable was coded as a dummy variable, δ_6; δ_6=1 for heads of households who had off-farm employment and δ_6=0 for those without off-farm employment. Off-farm employment offers an opportunity to diversify sources of income. All things being equal, off-farm employment would increase farmer's effective demand for goods and/or services that are not available from the farm. It was therefore hypothesised that farmers with off-farm employment would buy Napier rather than produce it on their farms. As such OFFARM was expected to carry a negative sign.

TLUCAT: Number of tropical livestock units (TLU) for cattle kept by a household. This was computed from the sum of tropical livestock units of species of cattle kept by a household at the time of the survey. A bull, cow, weaner and a calf were taken to be 1.2, 1.0, 0.5 and 0.2 TLU respectively based on the conversion indices suggested by Upton (1993). TLUCAT is a continuous variable. The number of animals kept was expected to positively influence the likelihood of a farmer to adopt as well as explain the level of adoption of Napier grass. This is because the higher the number of animals kept the higher the likelihood that the farmer will devote a larger portion of land to fodder production in order to meet their feed requirements.

(c) Market factors

Two market factors namely, milk price and household expenditure on purchased fodder, was examined in this study.

MLKPRICE: Average daily milk price in Kshs per litre. This variable is continuous indicating the amount of money paid for a litre of milk by various buyers at the time of the survey.

Generally, farmers react to price signals by adjusting the resources at their disposal to improve their well being (Odhiambo, 1998). In most cases, farmers base their production decisions on the input-output price ratio. All else being equal, high commodity prices induce farm families to search for more productive methods of generating a larger marketed output. In this study, the decision to adopt and the level of adoption of Napier grass by the smallholder dairy farmers in Kiambu district was hypothesised to be positively related to the price of milk.

FORPUR: Household expenditure on forage in Kenya shillings. FORPUR is a continuous variable that shows the amount of money spent on forage per annum.

Purchased fodder offers an alternative source of animal feed that complements forages cultivated on the farm. High fodder purchases substitute for on-farm fodder cultivation. It was therefore hypothesised that FORPUR would be negatively related to both the decision to adopt and to the level of adoption of Napier grass.

(d) Institutional factors

Three institutional factors namely, dairy co-operative/farmer self-help group membership, extension advice on planted forages and number of extension worker's visits 12 months prior to the date of the interview, were examined in this study.

COOPMEMB: Membership in a dairy co-operative society or farmer self-help group. This variable was coded as a dummy variable, δ_7; $\delta_7=1$ for a dairy co-operative/farmer self-help group member and $\delta_7=0$ for a non-member.

Owango *et al.* (1997) observed that dairy co-operative members benefit from veterinary and AI services, credit and loan facilities and livestock feed and drugs offered by the co-operative. Besides, dairy co-operatives provide a guaranteed milk market, especially when the milk market was not liberalised. Given that Napier grass is one of the major components of dairy cattle feed in smallholder farms, a guaranteed milk market and other support services provided by the dairy co-operatives may enhance its adoption. COOPMEMB was therefore hypothesised to carry a positive sign.

EXTADV: Whether a farmer had received specific information regarding planted forages from the local extension agent during the year preceding the date of the interview. EXTADV was coded as a dummy variable, δ_8; δ_8=1 if the farmer had received specific information from the extension agent and δ_8=0 otherwise.

Extension workers, besides informing farmers about new agricultural technologies, also demonstrate to the farmers how to plant and manage their forages for increased yield. This exposure, in effect, should have a positive impact on the likelihood of a farmer adopting the particular forage. In this study, EXTADV was hypothesised to be positively related to farmers' decision to adopt and the level of adoption of Napier grass.

TOTETVST: Number of extension workers' visits to the farmer during the year prior to the survey.

Farmers who are regularly visited by extension workers get information on new farming techniques and are therefore in a better position to initiate the adoption process compared to their counterparts who may rely on spill-overs from innovative farmers in their locality. In this study, it was expected that the number of extension workers' visits to the farmer would be positively related to the decision to adopt and the level of adoption of Napier grass as a dairy cattle feed.

The β_0 and β_i in the empirical model are, respectively, the intercept of NAPLAND$_i$ and coefficients of $\mathbf{x}_i$. ε_i is a stochastic disturbance term assumed to be normally and independently distributed with zero mean and constant variance σ^2.

3.6.1 Estimation procedure

The empirical model in equation (3.3) was estimated using data from the MoALDM/KARI/ILRI survey. Three models were sequentially employed to the data to obtain the likelihood estimates of β following the method of Goetz (1995):

(i) The probit model was applied to the entire sample to obtain factors that only influence the probability of adoption of Napier grass. Since the probit model utilises discrete (0/1) observations, all the non-zero observations were coded to 1.

(ii) The tobit model was fitted, again to the entire sample, to obtain β estimates of the factors that jointly influence the probability and the level of adoption of Napier grass. The expected value of the dependent variable, NAPLAND, was further disaggregated following McDonald and Moffitt (1980) (see below).

(iii) Finally, the truncated model was applied on the non-zero observations to assess factors that only influence the level of adoption of Napier grass.

The marginal effects of $\mathbf{x}_i$ in each model were also computed. The marginal effects give the change in the probability of adoption due to a one unit change in the exogenous variable[1]. According to Greene (1993), the marginal effects give information about the sample while the maximum likelihood estimates of β give information about the population from which the sample is drawn. The choice of which one to report depends on the inferences made about the estimates. In this study, both the β^{MLE} and the marginal effects were reported.

The method for disaggregating the effects of change in the expected value of NAPLAND with change in the independent variables was described by McDonald and Moffitt (1980) as follows: given the tobit model in equation (3.2) of Section 3.5.1, i.e.,

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[1] In the case of dummy variables such as sex of the household head, the marginal effect is the difference in probability due to belonging to one group rather than another (Nicholson *et al.*, 1998).

$$y_i^* = \beta'\mathbf{x}_i + \varepsilon_i,$$
$$y_i = y_i^* \quad \text{if} \quad y_i^* > 0$$
$$y_i = 0 \quad \text{if} \quad y_i^* \leq 0,$$

the expected value of y (NAPLAND in this case) is:

$$\mathrm{E}y = \beta'\mathbf{x}_i F(\mathrm{z}) + \sigma f(\mathrm{z}) \tag{3.4}$$

where $\mathrm{z} = \beta'\mathbf{x}_i/\sigma$ or the Z-score for the area under normal curve. $\mathbf{x}$ is a vector of explanatory variables, β is a vector of tobit maximum likelihood estimates and σ is the standard error of the error term. $F(\mathrm{z})$ is the cumulative normal distribution function of z, and $f(\mathrm{z})$ is the unit normal density obtained by the derivative of the normal curve at a given point. The expected value of y for observations above the limit, herein referred to as y' to distinguish it from the latent index variable, y^*, is a general mean, $\beta'\mathbf{x}_i$, plus the expected value of the truncated normal error term, i.e.,

$$\mathrm{E}y' = \beta'\mathbf{x}_i + \sigma f(\mathrm{z})/F(\mathrm{z}) \tag{3.5}$$

Thus, the relationship between the expected value of all observations, $\mathrm{E}y^*$, the expected value conditional upon being above the limit, $\mathrm{E}y'$, and the probability of being above the limit, $F(\mathrm{z})$, is:

$$\mathrm{E}y^* = F(\mathrm{z})\mathrm{E}y' \tag{3.6}$$

The total change in the expected value of y^* as the independent variable, $\mathbf{x}_i$, changes is:

$$\delta \mathrm{E}y^*/\delta \mathbf{x}_i = F(\mathrm{z})(\delta \mathrm{E}y'/\delta \mathbf{x}_i) + \mathrm{E}y'(\delta F(\mathrm{z})/\delta \mathbf{x}_i). \tag{3.7}$$

This can be broken down into two parts:

(i) the change in $\mathrm{E}y^*$ of those above the limit, weighted by the probability of being above the limit, i.e., $F(z)(\delta Ey'/\delta \mathbf{x}_i)$ and,

(ii) the change in the probability of being above the limit, weighted by the expected value of y if above, i.e., $Ey'(\delta F(z)/\delta \mathbf{x}_i)$.

The two partial derivatives in the right hand side of equation (3.7) were calculated from:

$$\delta Ey'/\delta \mathbf{x}_i = \beta_i[1 - zf(z)/F(z) - f(z)^2/F(z)^2] \quad (3.8)$$

and

$$\delta F(z)/\delta \mathbf{x}_i = f(z)\beta_i/\sigma. \quad (3.9)$$

β_is were obtained from the maximum likelihood estimates of the tobit model, $F(z)$ and $f(z)$ were read off from the cumulative and normal distribution tables respectively (Greene, 1993), while σ was obtained from the computer output.

3.6.2 Screening variables in the empirical model and assessing the goodness-of-fit

3.6.2.1 Screening variables in the empirical model

(a) Testing for degree of multicollinearity

A major problem in economic modelling is that of multicollinearity. The term multicollinearity is used to denote the presence of linear relationships between (or near linear relationships) among the explanatory variables (Koutsoyiannis, 1973: p. 233). The presence of multicollinearity reduces the precision of individual regression coefficients. This arises because the **|X'X|** matrix is not equal to zero resulting in indeterminate parameter estimates with infinitely large standard errors. As a result, hypothesis testing becomes weak so that diverse hypotheses about parameter values cannot be rejected (Kennedy, 1985). Multicollinearity is a sample problem and as such, it cannot be tested. Rather, what is testable is the degree of multicollinearity in the exogenous variables.

The seriousness of the effects of multicollinearity depends on the degree of intercorrelation as well as the overall correlation coefficient. As such, standard errors, the partial correlation coefficients and the overall R^2 may be used for testing for multicollinearity. However, none of these criteria by itself is a satisfactory indicator of multicollinearity. Koutsoyiannis (1973) suggests the use of a combination of all these criteria to detect multicollinearity. Accordingly, in this study, the seriousness of multicollinearity in the empirical model was detected by examining the standard errors of β estimates, looking at the partial correlation coefficients of the independent variables and the overall R^2. Examination of the standard errors of β estimates led to the suspicion of multicollinearity in BREED, FAMLAB, FORPUR and TOTETVST. Consequently, these variables were dropped from the empirical model. The Pearson correlation coefficient (ρ) was used to test the hypothesis of no multicollinearity (H_o:ρ=0) between any two variables in the correlation matrix. Kennedy (1985) states that a value of 0.8 or higher in absolute terms of one of the correlation coefficients indicates a high correlation between the two independent variables to which it refers. Based on this criterion, the partial correlation coefficients indicated non-existence of the problem of multicollinearity in the remaining variables (see Appendix III). Further examination of the overall R^2 values (as indicated by the likelihood ratio index, LRI, see next section) for the three models revealed no problem of multicollinearity in the remaining variables.

(b) Testing for heteroscedasticity

One of the major problems with cross-section data is the tendency of the disturbances (ε_is) to vary with some or all of the explanatory variables (Kennedy, 1985). This tendency violates the constant variance assumption of the disturbance term, resulting in heteroscedasticity. Heteroscedasticity renders the estimated βs inefficient and thus invalid for use in making predictions about the dependent variable (Greene, 1993). In addition, it also prevents the performance of normal statistical tests of significance and construction of confidence intervals.

In this study, heteroscedasticity in all the three models was tested using the likelihood ratio (LR) statistic. The null hypothesis was that the model in question is homoscedastic against the alternative that it is heteroscedastic. The heteroscedastic model was specified by adding HET$ command and estimating it according to Greene (1994: p. 598). The LR statistic is similar to the F test in OLS. It is asymptotically distributed as chi-squared with *k* degrees of freedom, where *k* is the number of independent variables in the model (Greene, 1993). The LR statistic was calculated from the following formula:

$$LR = -2(\ln L_{het} - \ln L_{hom}) \tag{3.10}$$

where $\ln L_{het}$ and $\ln L_{hom}$ are the heteroscedastic and homoscedastic log-likelihood functions respectively. The computed LR value for all the three models was zero while the tabulated χ^2 value at $\alpha=0.01$ and $k=11$ was 24.7. Since the calculated LR value was less than the tabulated χ^2 value, the null hypothesis of homoscedasticity could not be rejected for all the three models.

(c) Testing for normality

Normality was examined from the indices of skewness and kurtosis for the dependent variable, NAPLAND. Skewness measures the symmetry of the distribution curve about the mean while kurtosis is a measure of the peakedness of the distribution curve (Williams, 1993). The indices of skewness and kurtosis for the normal distribution curve are zero and 3 respectively. High indices of skewness and kurtosis indicate a normality problem; in which case assumption that the error term, ε, is normally distributed ceases to hold. In this study, the skewness and kurtosis indices for

NAPLAND were 2.0 and 7.7 respectively (see Appendix III), which are within the acceptable range for cross-sectional survey data. The dependent variable was therefore considered to be robust enough for use in the empirical model.

3.6.2.2 Assessing the goodness-of-fit

A goodness-of-fit measure is a summary statistic indicating the accuracy with which a model approximates the observed data. In the case where the dependent variables are qualitative, accuracy can be judged either in terms of the fit between the calculated probabilities or in terms of the model to forecast observed responses (Maddala, 1983). To measure the goodness-of-fit in qualitative response models, Greene (1993) suggests the use of the likelihood ratio index (LRI). The LRI (also called McFadden R^2 or pseudo R^2) is analogous to the R^2 in a conventional regression. It was computed from the following formula:

$$LRI = 1 - \ln L / \ln L_0 \qquad (3.11)$$

where $\ln L$ is the log-likelihood function value for the model having all the independent variables and $\ln L_0$ is the log-likelihood function value for the model computed with only the constant term. A zero LRI value indicates a perfect lack of fit while an LRI value of one indicates perfect fit. Empirical evidence suggests that LRI usually lies between 0.2 and 0.4 (Jarvis, 1990 quoted by Mbata, 1997).

3.6.3 Computation of the farm partial budget

A farm partial budget is a useful tool for comparing the performance of different farm enterprises. Generally, the computation of commodity gross margin requires the quantification and valuation of all inputs used in the production of that commodity. This quantification is not without problems as, in reality, the level and combination of inputs and outputs differ across time and space (van der Valk, 1992; Dillon and Anderson, 1990). Consequently, both input and output quantities need to be standardised in order to obtain figures that relate to the general situation (van der Valk, 1992). In this study, quantities of inputs used and outputs obtained from Napier grass and maize enterprises were given in different units. These units were converted into equivalent standard units to facilitate the calculation of enterprise gross margin.

As is the case with many smallholder farms, reliable farm production data were lacking as most farmers did not keep farm records. This forced the author to rely on the farmers' memory for information. One of the main shortcomings of such an exercise is that farmers may give biased and sometimes distorted figures, depending on the impression they want to make of the researcher. This introduces measurement error and decreases the quality of data in general (Staal and Omore, 1998). In this study, approximations were made whenever the reported data were considered insufficient or inaccurate for use in the calculation of enterprise gross margins. While such extrapolations may not give the accurate quantities of the items under investigation, they none-the-less highlight the general trend of the behaviour of the smallholder farmer, which may otherwise not be verified without incurring extra effort and cost.

The partial budget was computed from average input and output market prices for both Napier and maize enterprises. The product of prices and quantities of inputs were used to calculate the opportunity cost of producing the output(s). The term "opportunity cost" is defined here according to Mansfield (1988) who argues that "the cost of producing a certain product is the value of the other products that the resources used in its production could have produced" (p. 37). Under the assumption of perfect product and factor markets, enterprise gross margins were calculated from the following formula:

$$G_i = \sum Q_i P_o - \sum X_i P \quad (3.12)$$

where G_i is the gross margin for the *i*th enterprise, Q_i is the quantity of output from the *i*th enterprise, P_o is the output price, X_i is the quantity of input for the *i*th enterprise, P is the input price, and *i* represents either Napier or maize enterprises.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter has two parts. Part One summarises the results of descriptive analysis for both the author and the MoALDM/KARI/ILRI surveys in three sections. The first section focuses briefly on the major socio-economic characteristics of the Napier grass adopters and non-adopters. The second section presents the summary statistics for the author's survey, while the third section gives the partial budget computed from the author's survey data. Part Two of this chapter discusses the results of the econometric analysis.

4.2 Part One: Results of descriptive analysis

4.2.1 Section One: Socio-economic characteristics of adopters and non-adopters of Napier grass

Of the 365 households interviewed, 28%, 38% and 34% were in the tea/dairy, coffee/dairy and horticulture/dairy land-use zones respectively. About 93% (340) of all households were agricultural (i.e., they had and used land for farming); the rest (7%) were non-agricultural. The non-agricultural households were mostly located near the urban centres. This study concentrates on the 340 agricultural households. About 70% of the agricultural households had adopted[1] Napier grass at the time of the survey. Table 4.1 shows the proportion of Napier adopters and non-adopters in the three land use zones. From the table, 50%, 69% and 88% of the households in the tea/dairy, coffee/dairy and horticulture/dairy respectively had adopted the Napier grass technology at the time of the survey.

[1] In this study, an 'adopter' was considered to be any farmer that had some Napier grass on his farm at the time of the survey.

Table 4.1: Proportion of Napier grass adopters and non-adopters in each land-use zone

Class of farmers	Land-use zone			Total
	Tea/dairy	Coffee/dairy	Horticulture/dairy	
Adopters	50 (0.49)	81 (0.69)	106 (0.88)	237 (0.7)
Non-adopters	52 (0.51)	37 (0.31)	14 (0.12)	103 (0.3)
Total	102	118	120	340

Source: MoALDM/KARI/ILRI Survey, 1996
Figures in brackets refer to the proportion of adopters and non-adopters within the zone.

The average household size for all the 340 agricultural households was six members. The adopting and non-adopting households on average had 6.2 and 6.4 members respectively. The mean family size for the two groups of farmers was not significantly different (P>0.1). The mean age of the household heads in the adopting households was about 51 years while that of the non-adopting households was about 48 years. Although the mean age for the household head in the two groups was not significantly different (P>0.1), the results suggest that the non-adopters were, on average, about three years younger than the adopters. The majority of the household heads in both groups of households were males (Table 4.2). However, about a third of the non-adopters were women household heads. In 90% of all the agricultural households, the head was the farm manager. Farming was the primary activity for over 60% and 55% of the adopting and non-adopting household heads respectively.

In general, the adopting household heads had had more exposure to formal education than the heads of non-adopting households. In addition, women, 46% of whom were non-adopters, were less learned than their male counterparts (Table 4.2).

Table 4.2: Sex, age and level of education of household heads in the sample

	Adopters		Non-adopters	
	Males (%)	Females (%)	Males (%)	Females (%)
Sex	76	24	69	31
Average age (years)	50.3	51.7	47.2	49.6
Education Level				
No formal education	3	6	6	8
Primary level	3	1	1.5	0
Secondary level	34	12	41	16
Post secondary	26	4	17	3
Technical training	3	0	0	1.5
Adult literacy training	6	1.5	3	1.5
Other	0	0	<1	<1

Source: MoALDM/KARI/ILRI Survey, 1996

The adopting households hired more labour than the non-adopting households. Almost 50% of the total labour employed by the adopting households was casual labour (Table 4.3).

Table 4.3 Percentage of adopters and non-adopters who employed either family, casual or permanent labour

Source of labour	Adopters	Non-adopters
Family	29.4	46.8
Casual	49.5	46.0
Permanent	21.1	7.1

Source: MoALDM/KARI/ILRI Survey, 1996

The mean land size for the adopters and non-adopters was 1.2 and 0.8 hectares respectively and was significantly different ($P<0.01$). The overall mean land size for all the 340 agricultural households was 1.1 hectares. Most of the land was under freehold[1] tenure. Maize, beans, Irish potatoes, bananas and vegetables were the main food crops

[1] Freehold tenure is where the land owner has title to land (in Kenya referred to as title deed, which is a legal document testifying to land ownership) and can transact freely using such a title.

grown. The average area under maize was 0.2 and 0.1 hectares for the adopters and non-adopters respectively and was significantly different (P<0.05). Napier grass, the only fodder crop of importance, was grown by 60% of the farmers. In over 90% of the cases, Napier grass was grown as a sole stand. The mean area under Napier grass was 0.24 hectares. About 11% of the farmers grew fodder trees. The most common fodder species grown were *Grevillea*, *Leucaena*, *Sesbania*, and *Calliandra*.

Of the 340 agricultural households, 261 (78%) had dairy cattle. About 91% and 56% of the adopters and non-adopters respectively kept dairy cattle. The 261 dairy households kept a total of 784 cattle, giving an overall mean of three cattle per household. The mean herd size for the adopters and non-adopters was 3 and 2 cattle respectively and was significantly different (P<0.1). About 54% of these animals were dairy crosses; 43% were high dairy grades and about 4% were local (Zebu) breeds. The adopters kept 84%, 68% and 85% of Zebu, dairy crosses and dairy grade cattle respectively. The non-adopters, on the other hand, kept 16%, 32% and 15% of the Zebu, dairy crosses and dairy grade cattle respectively (Table 4.4). The dominant breeds in these dairy herds were Holstein-Friesian (51% of the breeds), Ayrshire (23%) and Guernsey (13%).

Table 4.4: Percentage of different kinds of cattle kept by adopters and non-adopters

Kind of cattle	% kept by adopters	% kept by non-adopters
Zebu	84	16
Dairy crosses	67.5	32.5
High dairy grade	84.6	15.4

Source: MoALDM/KARI/ILRI Survey, 1996

Of the 261 dairy households, 67% practised zero-grazing. Another 28% grazed their cattle on pasture while the rest (5%) used both types of grazing. Agro-industrial by-products were used as animal feeds in 16% of the dairy households, whereas 70% used commercial feeds. Two-thirds of the 340 households indicated that they experienced feed shortages especially during the dry season. To ameriolate the problem of feed shortage, farmers purchased fodder (45%), concentrates (7%), or used plants which are not normally used to feed cattle (10%).

About 51% and 21% of the adopters and non-adopters respectively used AI. This may be because more adopters than non-adopters had high grade dairy cattle (Table 4.4).

The most prevalent diseases in the survey area in order of importance were East Coast Fever (reported by 30% of the 340 respondents), anaplasmosis (11%), mastitis (10%) and intestinal worms (10%). Pneumonia and foot rot were less common and were reported by 5% and 3% of the 340 farmers respectively. These diseases were controlled through preventive or curative measures. The preventive measures used included vaccination (63%), use of antihelmintics (89%) and acaricides (71%) to control intestinal worms and ticks respectively. Curative use of anthelmintics was practised by 11% of the farmers.

At the time of the survey, 26% of the 784 cattle kept by the dairy households were in lactation. The overall mean daily milk yield was 6.8 litres. The mean daily milk yield for the adopters was 7.4 litres while that for the non-adopters was about 5 litres. These means were significantly different at the 1% level. The mean calving interval for herd in all the dairy households was 591 days, and an average lactation period of 388 days. Age at first calving varied between 30 and 40 months. These findings correspond to those of Omore (1997), who attributed similarly low productivity indicators to poor nutrition and poor breeding programmes among the smallholder dairy farmers in Kiambu district.

Table 4.5: Average milk yield, calving interval and lactation length for cows kept by the sample households

	Mean	Range
Daily milk yield (lts)	7.4	1-36
Calving interval (days)	591	273-1308
Lactation length (days)	388	30-1004

Source: MoALDM/KARI/ILRI Survey, 1996

Of the farmers who had surplus milk, 42% sold it to the dairy co-operative societies, 17% to individuals and 10% to itinerant milk traders. Milk was sold at an average price of Kshs 13.40 per litre (range=7-30). At the time of the survey, about 39% of the 261 dairy farmers were active dairy co-operative society members. The adopters and non-adopters made up 59% and 35% of the active dairy co-operative members respectively.

On average, the adopters obtained Kshs 5,800 per year from dairy related activities compared to Kshs 3,500 for the non-adopters. However, this income was not significantly different (P>0.1). About 31% of the adopters who had dairy cattle had off-farm employment. Among the non-adopters, only 15% of the households with dairy had off-farm income.

4.2.2 Section Two: Summary statistics for the author's survey

4.2.2.1 Napier grass production

Despite the categorisation of households into the three classes (see Section 3.3.2), all the 30 households interviewed in the author's survey had some Napier. This means that some of the households had switched to Napier grass production since the 1996 visit. According to Ruthenberg (1985), adoption is rarely a once-for-all process. Farmers tend to test what is proposed to them, and for some time the may alternate between practising and non-practising of the new technology (p. 113).

Asked when they started growing Napier grass in their farms, most (46%) of the respondents indicated that they started growing Napier grass in the 1980s. Another 38% started growing Napier grass in the 1990s and 8% each during the 1960s and 1970s (Table 4.6). The high rate of adoption of Napier grass in the 1980s may be attributed to the activities of the National Dairy Development Project (NDDP) which encouraged farmers to grow Napier grass for improved milk yield (KARI-NDDP, 1992; de Jong, 1996; Maarse *et al.*, 1998). Participation in the project required farmers to plant stands of Napier and to construct housing for grade and cross-bred cows before they could receive extension support (Nicholson *et al.*, 1998).

Table 4.6: Percentage of households and the year when they started growing Napier grass in Kiambu district

Year	% households
1960s	8.3
1970s	8.3
1980s	46.0
1990s	37.5

Source: Author's Survey, 1997

Of the 30 households surveyed, 48% had a dairy cow when they first introduced Napier grass in their farms. Two-thirds of the remainder started growing Napier before they got their first dairy cow, while the rest could not remember when they first planted Napier on their farms.

Over 50% of the respondents indicated that the primary reason for introducing Napier grass on their farms was for feeding their cattle. Other respondents gave the following reasons: soil conservation (11%), sale (14%), anticipation of buying a dairy cow in the near future (7%), ease of harvesting Napier (4%), feeding small ruminants (mainly goats) (4%), to minimise the cost of purchasing Napier grass outside the farm (4%) and to intensify land use (4%).

The initial decision to plant Napier grass on the farm had been made by the husband in about 38% of the cases, by the wife (31%), by both husband and wife (24%), and by father and daughter (3%) (Table 4.7). From the table, it seems that husbands had the greatest input to the decision to plant Napier grass. In the Kikuyu community (which inhabits the survey area), the men, who in most cases are the heads of households, dominate the decision making process. It is, therefore, likely that by being the major decision makers, the husbands were exercising their traditional role as stewards of households. Besides, in the 1980s the extension workers mainly focused on male heads of households on the assumption that channelling information and other goods and services through them would benefit the household as a whole (Poets and Russo, 1989 quoted by Maarse *et al.*, 1998). However, it seems as if this tendency is somehow changing if one considers the fact that in 24% of the households both husband and wife contributed in making the decision to plant Napier grass on their farms. In the 31% of the cases where the wife solely contributed to the decision, it is likely that the husband had off-farm employment so that the wife was left to manage the farm.

Table 4.7: Percentage of household heads who made the initial decision to grow Napier on their farms for the first time

Decision maker	% households
Husband	37.9
Wife	31.0
Husband & wife	24.1
Father & daughter	3.4

Source: Author's Survey, 1997

In 33% of the households, neighbours provided information about Napier grass while 17% of farmers obtained information from the extension workers. Another 22% of the farmers had previous experience on Napier grass production. This experience was derived from earlier employment in European farms or from farmers' area of origin. The fact that about a third of the households interviewed obtained information from their neighbours is indicative of the vital role that farmers play in the dissemination of agricultural information. By either "looking across the fence" or through casual contact with their neighbours, farmers learn from each other's experiences. A similar observation has been made by Maarse *et al.* (1998) in the case of farmers in the Coast Province. They noted that farmers in the Coast Province valued farmer-to-farmer exchanges more highly than extension advice. Farmer-to-farmer interaction occurs in a variety of ways including visual observation, verbal exchanges, and the physical exchange of items such as seed/grain, vegetatively propagated transplants and breeding stock (Grisley, 1994). From Table 4.8, it seems that farmer-to-farmer interaction was more important than the activities of the extension agents in the diffusion of Napier grass technology among the smallholder dairy farmers in Kiambu district.

Table 4.8: Sources of information about Napier grass in Kiambu district

Source	% households
Neighbours	33.3
Extension workers	16.7
Previous experience	22.2
Thought about it	27.8

Source: Author's Survey, 1997

Napier grass was popular among 36% of farmers because of its ability to yield high quantities of biomass compared to other grasses such as Kikuyu grass. Staal *et al.* (1997) indicate that land holding in Kiambu district is small and diminishing as the district's population increases. Thus, the popularity of the high biomass yielding Napier grass as reported by the sample farmers can be attributed to the need to conserve land for other agricultural purposes. Other reasons cited for choosing Napier grass rather than other grasses included the need to intensify land use (16%) and soil conservation (8%).

Of the 30 farmers interviewed, 71% used root splits as planting material while the rest (29%) planted Napier grass cane cuttings. The bulk of the planting material was borrowed from neighbours (65%), again emphasising the role of neighbours in the promotion of Napier in the study area. The rest of the material was obtained from extension workers/agricultural office (3.8%) and relatives (7.7%). Only one farmer bought the planting material (Table 4.9). This observation further shows the diminished role of extension workers in the promotion of Napier grass technology among farmers in the study sample.

Table 4.9: Sources of planting material and the proportion of farmers who reported them

Source of planting material	No. of farmers
Old Napier plot	4 (0.15)
Extension/Agricultural office	1 (0.04)
Neighbour	17 (0.65)
Bought	1 (0.04)
Relatives	2 (0.08)
Other	1 (0.04)
Total	26 (1.00)

Source: Author's Survey, 1997
Figures in brackets represent proportions

Farmers gave a variety of responses concerning their choice of the planting material. These responses included rapid tillering of Napier grass (12.5%), absence of hair on the planting material (8.3%), and recommendation by the extension worker(s) (4.2%). About 8% of the farmers had no specific reason for their choice. According to Lowe *et al.* (1996), Napier grass can withstand repeated cutting and has a rapid tillering ability which leads to the production of highly palatable leaf biomass. These characteristics are important if one considers the small and dwindling land holdings in Kiambu district. About 24% of the farmers considered land size before making their decision to introduce Napier grass in their farms. This consideration is rather obvious given the small land sizes in Kiambu district. Another 19% had considered the herd size, while 14% considered household food requirements. Other factors taken into account were soil erosion (10%), land tenure (5%), availability of other fodders (5%), the need to sell Napier grass (5%) and labour constraints to work on the rest of the farm (5%).

All the 30 households had a homestead plot of Napier. For those who had other Napier plots elsewhere, the mean distance from the homestead was 2.6 km (s.d.=3.7). The mean plot size was quite small at 0.15 ha (s.d.=0.19). This result corresponds well with the small land holdings in Kiambu district. About 50% of the farmers planted Napier on the steep part of their farms probably to control soil erosion.

Over 60% of the farmers rotated their Napier plots at least once every two years. Rotation was based on the tillering ability of Napier grass, appearance of foliage and age of stand since the last rotation for 50%, 23% and 3% of farmers respectively. These criteria for rotation seemed to correlate with the soil fertility status of the plot. During the rotation, Napier grass was usually alternated with food crops, mainly maize and potatoes. Some respondents claimed that alternating Napier with food crops helped to reduce the incidence of disease and invasion of crops by rodents.

About 41% of the households farmed on the roadside plots. Of these, 50%, 31% and 6% grew Napier grass, maize, and Irish potatoes respectively on those plots. Cultivation of roadside plots is an important indicator of land scarcity in Kiambu district. The permission to utilise roadside plots was granted by either the assistant chief or owner of land adjacent to the Napier plot if such owner was not already utilising it. Over 80% of the farmers said that they managed the roadside plots like their own farms probably indicating how much they valued those plots.

4.2.2.2 Sources of fodder

1. Crop residues

The utilisation of crop residues as a source of feed is one of the main factors characterising smallholder farming in Kenya. It depicts the level of complementarity between livestock and crop production as farm size diminishes. According to de Leeuw (1997), reliance on crop residues increases as farm size decreases and as stocking rates increase. By use of crop residues to feed their livestock, farmers maximise the use of local natural resources on their farms to raise the human carrying capacity (Waters-Bayer and Bayer, 1992).

In this study, utilisation of crop residues varied with the seasonal availability of the particular crop. Correspondingly, green maize stover was used by 75% of farmers after the long rains (March-May). Dry stover, available after the September harvest, was used by 80% of the farmers. Banana pseudo-stems were used throughout the year, especially during the dry season. Sweet potato vines and bean haulms were used in small quantities whenever they were available. The sweet potato vines were mostly used at milking. Surplus and spoilt kale was used during the long rains by one-third of the households (Table 4.10).

Table 4.10: Utilisation of crop residues during different periods of the year

	Crop Residue					
	Green stover	Dry stover	Banana stems	Sweet potato vines	Bean haulms	Kale
Period of use	% of farmers that used the crop residue to feed livestock					
Long-Dry (Jan-Mar)	10.0	40	50	0.0	0.0	0.0
Long-Wet (Mar-May)	33.3	0.0	0.0	33.3	0.0	33.3
Short-Dry (Jun-Aug)	75.0	0.0	0.0	15	5.0	5.0
Short-Wet (Sep-Dec)	13.3	80	0.0	6.7	0.0	0.0
All year round	20.0	20	60.0	0.0	0.0	0.0
Intermittently	0.0	6.7	33.3	46.6	13.3	0.0

Source: Author's Survey, 1997

2. Other planted fodders

Only 13% of the sample farmers grew fodder trees. The most common fodder tree species grown were *Leucaena leucocephala*, *Grevillea robusta* and *Calliandra calothyrus*. According to de Jong (1996), fodder trees were introduced in NDDP target districts (Kiambu was one of them) in 1990 for dry season feeding to even out irregular concentrates supply. While many reasons may be responsible for the low diffusion of fodder tree technology in Kiambu district, it seems as if extension efforts to promote these forages have been lacking as evidenced by the fact that most farmers did not even know how these species look like.

3. Gathered fodders

Although about 70% of the surveyed farmers gathered fodder from their farms, only 13% gathered them outside their farms. The gathered fodder were mainly grass clippings and farm weeds from the compound and coffee plantations respectively. The gathered fodder supplemented Napier grown on the farm. In 60% and 10% of the households respectively, family and hired labour were used to gather fodder. Of the households that utilised family labour, the wife contributed about 61% of the labour force while the husband contributed approximately one-third as much. Children contributed half as much labour as their fathers to fodder collection. This observation indicates a clear division of labour among the family members in the study sample and it corresponds to that of the NDDP (1990) who found that women were more involved than men in dairying activities such as cutting of fodder, carrying grass and feeding cows. In the Kikuyu community, females are usually responsible for weeding. Thus, it is likely that the wives contributed the greatest proportion of family labour for gathering on-farm fodder as they were more involved in weeding than their husbands.

Of the households that gathered fodder outside the farms, 50% obtained farm weeds from their neighbours' farms while 38% cut grass from road reserves and nearby public institutions - schools, churches and tea or coffee factories. The rest of the households bought grass from roadside markets. Off-farm gathered fodders were mainly used to supplement cultivated and on-farm gathered fodders, especially during the dry season.

4. Purchased fodders

Approximately 47% of the households purchased fodder during the 12 months prior to the survey. Of these, 27% bought Napier grass alone while the rest, in addition to buying Napier grass, also bought maize stover, grass, banana stems and wheat straw. One farmer bought maize stover and banana pseudo-stems, while another bought grass clippings from coffee plantations (Table 4.11). Purchased fodder, like gathered fodder, supplemented cultivated fodders on the farm.

Table 4.11: Composition of fodder purchased by smallholder dairy farmers in Kiambu district

Combination of fodder	No. of farmers
Napier grass alone	4 (0.29)
Napier grass + others	8 (0. 57)
Maize stover + banana pseudo-stems	1 (0.07)
Grass alone	1 (0.07)
Total	14 (1.00)

Source: Author's Survey, 1997

Fodder prices varied with seasons and type of fodder sold. For example, a hectare of Napier grass, on average, sold at Kshs 22,230 during the long dry season (January-March) and Kshs 21,736 during the short wet season (September-December). Similarly, a hectare of dry maize stover sold at Kshs 4,199 during the short-wet season. One woman-load (about 25 kg total fresh weight) of green maize stover cost Kshs 40 and Kshs 60 in the long-dry and short-dry seasons respectively. On the other hand, a banana pseudo-stem was sold at Kshs 20 on average. The price of a banana pseudo-stem depended on its size and the season of purchase. Grass clippings sold for Kshs 300 a pick-up while a bale of wheat straw went for a mean price of Kshs 135 during the year preceding the survey.

Fodder was mainly sold by neighbours who did not have cattle. This was reported by 65% of the respondents. Other sellers included neighbours with surplus fodder (19%) and roadside markets (8%). Although the fodder was sold for cash in most (79%) cases, 8% of the farmers bought on credit while another 12% made advance payments. Only one farmer bartered Napier grass for milk. Napier grass and maize stover were the main fodders sold.

(a) Napier grass purchases

About 43% of the sample farmers purchased Napier grass. Three-quarters of those who did not buy Napier indicated that they grew enough fodder on their farms; another 13% expressed the willingness to buy but lacked fodder markets in their locality, while another 13% said they had alternative sources of fodder. The latter group of farmers was in the neighbourhood of a forest belonging to KARI.

Napier grass prices were determined by its seasonal availability, as indicated by 39% of respondents; quantity sold (28%), foliage colour (6%), terms of purchase (6%), type of seller (11%), and the compactness of the stand (6%).

(b) Maize stover purchases

Compared to Napier grass, maize stover was less popular to farmers in that only 23% of them bought it during the 12 months period preceding the survey. Most farmers indicated that they did not like maize stover because of its low contribution to milk yield. One farmer also claimed that it induced coughing in cattle. Of the 23 farmers who did not buy maize stover, 44% indicated that they had enough fodder, 28% did not regard dairying as an important activity in their farms, while another 11% had no specific reason for not buying maize stover. About 30% of the buyers indicated that the price was determined by seasonal availability and quantity of stover sold. A majority (71%) of the buyers indicated that they preferred green to dry stover because of its relatively higher palatability and contribution to milk yield.

4.2.2.3 Constraints to Napier production

The production of Napier grass in the survey area was mainly affected by moles and head smut as reported by 47% and 19% of the respondents respectively. Head smut is a fungal disease which causes early flowering and stunts Napier stands (Lusweti *et al*., 1997). The disease was common in Githunguri and Lari divisions located in the coffee/dairy and tea/dairy zones respectively. According to the respondents, moles were a great menace to both food and fodder crops in the survey area. Other factors which adversely affected Napier grass included drought (reported by 14% of the respondents), frost (6%) - reported by farmers in the cooler parts of the district - and weed infestation (3%).

To counter some of these problems, 70% of the farmers trapped the moles while 20% uprooted and either burned or buried Napier stands infected with head smut. Only 3% of the sample farmers used pesticides to control moles.

4.2.2.4 Farmers' fodder preferences

To get farmers' preferences for different fodders, the respondents were asked to rank fodders according to their perceived criteria. To get the rank, a score was computed from the mode of reported rank as shown in Table 4.12. The table indicates that Napier grass was the most popular feed known to farmers based on its contribution to milk yield. Green maize stover and farm weeds were in the second and third positions respectively. In some cases, the respondents indicated that these two fodders could replace Napier grass without drastically lowering the level of milk production.

4.2.2.5 Use of fertilisers in the production of Napier grass

Farmers in the survey area used both organic (manure) and inorganic (commercial) fertilisers in the production of Napier grass.

(a) Use of commercial fertilisers

About 47% of the households surveyed applied commercial fertilisers on Napier. The most widely used commercial fertilisers were calcium ammonium nitrate (CAN) and diammonium phosphate (DAP) reported by 41% and 27% of the respondents respectively. The rest of the farmers used other nitrogen-phosphorous-potassium (NPK) fertilisers besides CAN (14%), triple-super phosphate (TSP) (5%) and urea (5%).

Table 4.12: Ranking of reported fodders indicating farmers' perceived preferences

Fodder	Reported rank	Mode of households in the reported rank (A)	Total households which reported the fodder (B)	Score =(A*B)/92	Computed rank
Napier grass	1	12	18	2.35	1
Green maize stover	3	7	16	1.22	2
Dry maize stover	5	4	11	0.478	6
Banana stems	4	4	10	0.435	7
Sweet potato vines	3	5	10	0.534	5
Roadside grass	4	4	13	0.565	4
Farm weeds	4	7	12	0.913	3
Tree fodders	4	1	2	0.02	8
Total			92		

Source: Author's Survey, 1997

About 30% of the farmers who did not use commercial fertilisers decried their high cost. Approximately 35% of the rest felt that their farms were fertile. Most of the non-users were in Ndeiya sub-location. According to some of the respondents, the government gave out farms in Ndeiya sub-location after Kenya's independence in 1963. As such, these farms still possess their inherent soil fertility compared to farms in other sub-locations where cultivation has been going on for a longer period of time. The other reasons given for not using commercial fertilisers were the preference for animal manure (18%) and the observation that inorganic fertilisers 'burn' Napier grass (6%). About 6% of the non-users claimed that they lacked the technical know-how to apply fertiliser.

About 50% of the farmers who used commercial fertilisers on Napier applied them once per year; 40% applied twice per year and the rest (10%) thrice per year or once after every cutting. Application of commercial fertilisers was not based on the type of crop grown in 77% of the cases. According some respondents, there was no much competition between Napier grass and other crops for commercial fertilisers because Napier grass was fertilised at the time when the other crops were off-season. Besides, some farmers used specific commercial fertilisers for Napier grass. These commercial fertilisers were obtained from coffee or tea co-operative societies.

Of the 23% of farmers who gave priority to particular crops when applying commercial fertilisers, 63% gave first priority to food crops, 25% to cash crops and 13% to Napier grass. Although only a small number of farmers responded to this question, the fact that over half of them gave first priority to food crops suggests that most farmers sought to satisfy the household food requirements before embarking on the production of other crops. This finding differs significantly from Ruthenberg's (1985, p. 124) observation that farmers tend to apply fertilisers to cash crops first and then gradually there is a spill-over to subsistence crops. The 13% of farmers who fertilised Napier last were probably those to whom dairying was not an important farm enterprise.

(b) Use of animal manure

Slightly more (50%) farmers used animal manure on Napier grass than in the case of commercial fertilisers. This may be because manure was cheaply available in most homesteads that kept livestock. Of these, 76% produced manure on their farms while another 22% bought manure outside their farms. Farmers also applied manure to maize and beans, kale and Irish potatoes. About 34% of the households used compost manure while 32% used boma manure straight from the cowshed. In some cases, boma manure was either heaped outside the cowshed or left to decompose inside the shed. On several occasions especially during the wet season, the cowshed was cleaned to remove slurry. This slurry was later poured onto stumps of freshly cut Napier.

Farmers applied different types of manure to different crops depending on the texture of the manure. For instance, poultry and kraal[1] manure were used for planting maize and vegetable seedlings (especially kale). It was argued that these two types of manure were fine in texture and could therefore be easily applied on maize and vegetables just like the commercial fertilisers. The coarse textured compost manure, on the other hand, was applied on Napier and Irish potatoes.

Approximately 37% of the households bought manure from the Rift Valley Province. Others (36%) bought sifted poultry waste from their neighbours. According to Roothaert and Matthewman (1992) quoted in Odongo *et al.* (1998), poultry waste is a mixture of bedding material and excreta with a crude protein content of between 17% and 31%. Most of the waste was used to feed cattle. Farmers mixed the poultry waste with maize germ and maize bran to improve their nitrogen content. The leftovers from this feeding were used for fertilising maize and vegetables plots at planting. The use of poultry waste as a source of cheap nitrogen for cattle demonstrates an excellent case of nutrient cycling where the farmer utilises the available farm resources in such a way as to maximise the marginal returns from a unit of input. Odongo *et al.* (1998) have shown that increasing the proportion of poultry waste up to 80% when mixed with maize germ significantly improved milk production and reduced the cost of producing a litre of milk.

Over 93% of the farmers bought manure for cash. Only one farmer bartered manure with green maize stover. About 77% of the households that had cattle utilised animal urine as an organic fertiliser.

4.2.2.6 Marketing of fodders

This study also evaluated the marketing of Napier grass and maize stover, the two most popular fodders in Kiambu district. The data obtained from this section were used to

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[1] Kraal manure was bought from Maasailand in the neighbouring Rift Valley Province. This type of manure is usually of fine texture.

compute a partial budget that showed the trade-offs made by farmers in the production of the two fodders.

(a) Marketing of Napier grass

Thirty per cent of the households surveyed sold Napier grass. Of these farmers, 67% did not have cattle. In 50% and 30% of the cases, respectively, the cattle had either died or been sold at the time of the survey. The remaining 33% of the sellers sold Napier for cash. In 22% of the cases, farmers made advance payments for Napier while another 22% exchanged it for either milk or food crops. Advance payments assured a buyer of a regular supply of fodder throughout the year. The tendency to make advanced payments for Napier suggests high demand for this commodity in some parts of Kiambu district.

About 90% of the sellers said that the price of Napier grass varied according to seasons. This variation was attributed to the availability of other fodders during the season. In 60% and 40% of the households respectively, the wives and husbands sold Napier grass. In about 75% of the sales made, purchases were made at the farm-gate, while the remaining 25% of the households sold Napier at the roadside markets. The decision to buy Napier was influenced by the quantity offered in 62% of the cases. In 23% other cases, buyers considered the colour of the foliage before making the decision to buy a stand of Napier. Over 60% of the respondents indicated that these preferences varied with season.

(b) Marketing of maize stover

Maize is one of the major food crops in Kenya. Consequently, maize stover, its main by-product, is one of the most abundant crop residue on smallholder farms (Methu, 1996). In this study, all the households interviewed grew maize. However, only 20% of the households that grew maize sold stover suggesting that trade in maize stover was not as pronounced in the study area as that in Napier. The cattle belonging to 50% of the stover sellers had died.

In 67% of the households that grew maize sold the stover for cash. Other farmers made advance payment (22%) while others bought it on credit (11%). The price of maize stover, like that of Napier grass, varied with season as reported by 80% of the respondents. The determinants of price variation included the seasonal availability of maize stover (40%), availability of other fodder during the season (20%) and the quantity of stover sold (20%).

In contrast to Napier grass, the husbands in 60% of the households sold maize stover. In 60% of the cases, purchases were made at the farm. Buyers preferred green to dry stover as the former led to higher milk yields than the latter. The tendency to favour green over dry maize stover varied with seasons in 75% of the cases.

4.2.3 Section Three: Farm partial budgeting

The results in this section were obtained from the author's survey data. The analysis involved the computation of gross margins based on average quantities and prices of inputs and outputs from Napier and maize enterprises. The product of price and quantity of input used in each enterprise gave the opportunity cost for that enterprise. In all cases, the opportunity cost of land was assumed to be the same for all households and hence excluded from the gross margin calculations. This assumption was made in order not to overestimate the enterprise gross margins.

4.2.3.1 Production cost in Napier grass and maize enterprises

Input cost items for the production of both Napier grass and maize were labour, fertiliser, manure and planting material (Tables 4.13 and 4.14). The planting materials for the Napier and maize enterprises were cane cuttings and/or root splits and seed maize respectively. In both enterprises, labour was employed for land preparation, planting, applying both organic and inorganic fertilisers, and weeding. In addition, labour was used for cutting, carrying and processing Napier grass. In the maize enterprise, labour was also used for thinning, leaf stripping and maize harvesting.

Family and hired labour were used in the two enterprises. Irrespective of the source, labour was employed on the basis of an hour, half-day, day, week or month. These units were converted into eight-hour working day equivalent to facilitate the calculation of the opportunity cost of labour. Family labour was valued at the prevailing market wage rate. The calculated mean wage rate for an eight-hour working day was Kshs 80. On average, farmers used 6.3 and 6.4 days of family and hired labour respectively, spending about Kshs 1,019 for labour per year per hectare of Napier grass (Table 4.13).

The average usage of commercial fertilisers on Napier grass by the 30 farmers in the study sample was 95.2kgs/ha/yr. The calculated average price of inorganic fertiliser was Kshs 17/kg. Therefore, the average cost of commercial fertilisers used on Napier grass was Kshs 1,618/ha/yr (Table 4.13).

Table 4.13: Proportion of households using various inputs and the average cost (Kshs/yr) of producing a hectare of Napier grass in Kiambu district

Input	Number of households that applied the input	Average quantity of input for 30 households	Unit price (Kshs)	Average cost (Kshs)
Family labour[a]	19	6.3 days	80	507
Hired labour	12	6.4 days	80	512
Manure	15	2 tonnes	574	1,148
Commercial fertilisers	14	95.2 kgs	17	1,618
Planting material	---	---	---	---
				Total 3,785

Source: Author's Survey, 1997

[a] Opportunity cost based on observed market wage rate.

Animal manure was used on the basis of *debe*, 50, 70 and 90 kg sacks, wheelbarrow or pick-up. These units were converted into tonne equivalent. A *debe* of animal manure weighed 18 kg. A wheelbarrow of manure was equivalent to three *debe*s (or 54 kgs) while a pick-up was estimated to carry a tonne of animal manure[1]. On average, the 30 sample households used two tonnes of manure per hectare per annum on Napier. The calculated average price of a tonne of manure was Kshs 574. Thus, the average cost of animal manure was Kshs 1,148/ha/yr.

The cost of the Napier planting material could not be estimated because all but one farmer obtained it free of charge (see Table 4.9 in Section 4.2.2.1). Farmers in the study sample used 614 and 626 hybrid seed maize varieties. The 30 households had, on average, used 18.4 kg of seed maize per hectare 12 months preceding the interview. A

[1]The author acknowledges the fact that similar volumes of different types of animal manure have different weights. However, a flat rate was used due to lack of reliable weight data for each type.

kg of seed maize cost Kshs 70. Thus, the average cost of seed maize was Kshs 1,288/ha/yr (Table 4.14).

Table 4.14: Proportion of households using various inputs and the average cost (Kshs/yr) of producing a hectare of maize in Kiambu district

Input	Number of households that applied the input	Average quantity of input for 30 households	Unit price (Kshs)	Average cost (Kshs)
Family labour[a]	20	8 days	80	640
Hired labour	16	15.5 days	80	1,240
Manure	13	1.7 tonnes	574	976
Commercial fertiliser	18	51.6 kgs	17	877
Maize seeds	24	18.4 kgs	70	1,288
				Total 5,021

Source: Author's Survey, 1997

[a] Opportunity cost based on observed market wage rate.

4.2.3.2 Sale of Napier grass

(a) Assumptions and conversions

Several studies have reported Napier grass yields under different agronomic conditions in different parts of Kenya (see KARI-NDDP (1992) for a review). On-farm surveys conducted by the National Dairy Development Project (NDDP) during the 1983-1986 period report a mean yield of 13.5 t DM/ha/yr in Kiambu district (Woulters, 1987; Metz, 1994). Using dry matter (DM):fresh weight (FW) ratio of 20%[1], the 13.5 t DM/ha/yr approximate to 67.5 t/ha/yr fresh weight. Majority of farmers in the study area sold Napier on the basis of an acre plot and 50-metre rows. One farmer sold his Napier on basis of donkey cart-load. Consequently, the following conversions were made:

[1] Wachira (1996) used the same figure in similar calculations.

(i) Acre of Napier grass

Since one hectare produces 67.5 tonnes of Napier grass fresh weight, an acre of Napier would produce 27.3 tonnes *ceteris paribus*. As noted elsewhere, there was no unique market price for Napier. An acre (27.3 tonnes) of Napier grass was sold between Kshs 3,200 and 9,600, equivalent to Kshs 0.10-0.35/kg. The wide price variation probably reflected the relative scarcity of Napier grass in different parts of the district or even the seasonal availability of Napier grass. Errors in measurement could also have contributed to the wide price variation as most of the information was derived from the farmer's memory.

(ii) 50-metre row

The recommended standard spacing for Napier grass is 100 × 100 cm (Mureithi *et al.*, 1996). Therefore, one 50M-row of Napier has 51 stands. Since one hectare produces 67.5 tonnes, then one 50M-row (0.005ha) produces 0.34 tonne per year. The reported price for one 50M-row (0.34 tonne) of Napier varied between Kshs 80 and 350, which is equivalent to Kshs 0.20-1.0/kg. As in the case of acres of Napier mentioned above, the wide price variation probably reflected its relative scarcity. Of interest, however, is the fact that Napier prices also differed depending on the unit of sale. From these calculations, the smaller the unit of sale, the higher was the calculated price of Napier.

(iii) Donkey cart-load

The average weight of a donkey cart-load of freshly cut Napier grass was measured at 225 kg. A donkey cart-load sold at Kshs 3,400. This is equivalent to Kshs 15.10/kg. Because only one farmer used this unit, it was excluded from the calculations.

From these standardised units, the calculated average price of a kg of Napier was Kshs 0.3 fresh weight. This gave a mean value of Kshs 21,330 per year per hectare of Napier.

(b) Gross margin of the Napier enterprise

Value of Napier grass (Kshs/ha/yr)	= Kshs 21,330
Less	
Average cost of inputs (Kshs/ha/yr)	= (Kshs 3,785)
Gross margin (Kshs/ha/yr)	= Kshs 17,545

From these results, the gross margin for Napier production is positive.

4.2.3.3 Sale of maize stover and grains

(a) Sale of maize stover - assumptions and conversions

Output from maize production in smallholder farms has a multi-purpose use. Firstly, and perhaps the most important, maize is a source of food for humans. Secondly, spoilt maize grains are used as cattle feed. Thirdly, green[1] and dry stover are used to feed livestock. In this study, maize stover was sold on the basis of acre plots and pick-up loads. These units were standardised to facilitate the comparison of cost and value items.

(i) Acre of maize stover

In a study to evaluate the nutritive value of maize forage silage fed to dairy cows conducted in KARI-Muguga by Abate (1990), an hectare of maize stover produced 5.2 t $DMyr^{-1}$. Using DM:FW ratio of 80% (Wachira, 1996), one hectare would produce 6.5 tonnes of maize stover per annum, holding other factors constant. In this study, the reported stover price varied between Kshs 1,977 and 8,237/ha, equivalent to Kshs 0.30-1.30/kg. This price is higher compared to that of an equivalent quantity of Napier. The

[1] This comprises immature maize plants (thinnings) as well as mature but green stover.

price difference for the two fodders may be due to fact that very few farmers sold maize stover such that there was less price variation for maize stover.

(ii) Pick-up

A pick-up of fresh stover was assumed to weigh one tonne. At the time of the survey, a pick-up of maize stover was selling at Kshs 350 or Kshs 0.35/kg. The calculated mean price of a kg of dry maize stover was Kshs 0.70.

(b) Sale of maize grains - assumptions and conversions

Several farmers in the study gave maize output in terms of bags of unthreshed maize. There was therefore need to convert the reported maize output into bags of threshed maize, the form in which dry maize was reportedly sold. Consequently, grain:cob[1] ratio of 2:3 was used to convert unthreshed into threshed maize. This ratio was derived from the regression equation $Y = 0.68X$ reported by de Leeuw and Nyambaka (1995), where Y and X are weights (g plant^{-1}) of grain and cob, respectively, with the assumption that the husks had been removed.

Some farmers also sold green maize allegedly to prevent theft. Other farmers, especially those near the urban areas, indicated that green maize fetched higher prices than dry maize. Others indicated that this was also a strategy to utilise maize stover when it is still green and thus more nutritious to the cow for higher milk yield.

The value of maize was derived from mean monthly dry and green maize prices for July 1997 when the study was conducted. These prices were obtained from the MoALDM Market Information Branch, Nairobi. The mean dry maize price was Kshs 1,520 per 90 kg bag or Kshs 16.90/kg. An extended bag of green maize, weighing 115 kg, sold at an average price of Kshs 1,752 or Kshs 15.30/kg. The results of the calculations are

[1] This ratio was based on weight.

presented in Table 4.15 below. These calculations do not include the marketing cost of green maize because of lack of data; green maize is usually marketed informally.

Table 4.15: Mean annual value (Kshs/ha/yr) of a hectare of maize

Item	Price (Kshs/kg)	Mean annual value (Kshs)
1,310 kgs of dry maize	16.90	22,139
2,026 kgs of green maize	15.30	30,998
6,500 kgs of maize stover	0.70	4,550
Total		57,687

Source: Author's Survey, 1997

(b) Gross margin of the maize enterprise

Value of maize stover (Kshs/ha/yr)	= Kshs 4,550
Value of maize (green & dry) (Kshs/ha/yr)	= Kshs 53,137

Less

Average cost of inputs (Kshs/ha/yr)	= (Kshs 5,021)
Gross margin (Kshs/ha/yr)	= Kshs 52,666

The estimated average price of Kshs 0.30 per kg (fresh weight) of Napier is slightly higher than Wachira's (1996) estimate of Kshs 0.20 and 0.25 for Kamirithu and Kabuku sub-locations respectively, both of which are in Kiambu district. For maize stover, Wachira (1996) estimated a price of Kshs 0.25 and 0.30 for Kamirithu and Kabuku sub-locations respectively. This study found an average price of Kshs 0.70 per kg of maize stover, which is twice as high as Wachira's estimation, but Kshs 0.38 lower than that estimated by Onim *et al*. (1986) for Western Kenya.

From Tables 4.13 and 4.14, the average opportunity cost for the Napier and maize enterprises was Kshs 3,785 and Kshs 5,021 respectively. On average, farmers spent more on labour for the maize enterprise than for the Napier enterprise. However, they applied more fertiliser on Napier than on maize. The gross margins for the maize and Napier enterprises were Kshs 52,666 and Kshs 17,545 per hectare per year respectively. As such, the gross margin of the maize enterprise was three times that of the Napier enterprise. About 53% of the total mean annual value of maize came from the sale of green maize; dry maize accounted for about 38% while maize stover contributed 8% to this value.

These results suggest that without considering the fixed costs and marketing cost for green maize, farmers would obtain more returns per hectare if they produced maize rather than Napier grass for sale. However, one should bear in mind that in most cases farmers produce both Napier grass and maize in an effort to maximise returns from their farms. Furthermore, and as already noted elsewhere, Napier grass is an important input in the dairy enterprise and its role in the dairy enterprise cannot be adequately substituted by maize stover. As Muyekho *et al.* (1998) noted, maize stover has low crude protein and digestibility indices. The positive gross margin for the Napier enterprise found by this study probably indicates that Napier grass is an important source of income for the smallholder farmers in Kiambu district.

4.3 Part Two: Results of econometric analysis

This part presents the results of the econometric analysis. The analysis utilised the MoALDM/KARI/ILRI survey data to evaluate factors that influence farmers' decision to adopt Napier grass in smallholder dairying. Both the maximum likelihood estimates and marginal effects of exogenous variables are reported for all the three models. As indicated in Chapter Three, the problem of multicollinearity was suspected in BREED, ZON3, FAMLAB, FORPUR and TOTETVST[1]. Consequently, these variables were dropped from the empirical model to avoid prefect collinearity.

4.3.1 Factors influencing the probability of adoption of Napier grass

The probability of adoption of Napier grass, defined here as the likelihood that a farmer in the study sample will grow Napier grass on his/her farm, was assessed using the probit model. The results on Table 4.16 give a high explanatory power of 0.59. This means that the model correctly predicts 60% of the responses. In a similar study at the Kenyan coast, Nicholson *et al.* (1998) reported an explanatory power of 0.39. The results further indicate that years of formal education for the household head (EDUC), belonging to the horticulture/dairy zone (ZON1), having off-farm employment (OFFARM), milk price (MLKPRICE), and being a dairy co-operative/farmer organisation member (COOPMEMB), had a significant influence on the probability of adoption of the Napier technology. Apart from the coefficient on MLKPRICE that had a negative sign, all the other significant variables were positively related to the probability of adoption of Napier.

The fairly weak but significant ($P<0.1$) positive relationship between education and the probability of adoption of the Napier technology among farmers in Kiambu district

[1] More specifically, inclusion of these variables in the model resulted in the non-convergence of the model parameters under the Newton's optimisation criterion (See Greene, 1994, p. 112 for details).

agrees with those of Gerhart (1975), Rosenzweig (1978) and Jamison and Lau (1982) (quoted in Feder *et al.*, 1985). Gerhart found that the likelihood of adoption of hybrid maize in Kenya was positively related to education. Rosenzweig also found that the probability of adoption of high yielding grain in the Punjab was positively related to education and farm size. Jamison and Lau, while analysing the adoption of chemical inputs in Thailand, found that education affects the probability of adoption positively. Other studies have shown that formal schooling plays an important role in determining both farmer's allocative and entrepreneurial ability where the latter is defined as "the ability to perceive, interpret, and respond to new events in the context of risk" (Schultz, 1981, p. 25).

The coefficient on ZON1 had the expected positive sign and was statistically significant ($P<0.05$). According to Hassan (1996), farmers adopt different cropping systems to fit different agro-ecological and socio-economic circumstances. They then decide on the production methods and technologies best suited for the prevailing environment and system of farming. In this study, the positive sign on ZON1 suggests that farmers in the horticulture/dairy zone were more likely to adopt Napier than farmers in the other two zones. This is probably because farmers in the horticulture/dairy zone have more flexibility in altering their enterprise mix compared to those in either the coffee/ or tea/dairy zones where the law is more restrictive unless the alteration of the enterprise mix is either authorised by the Minister or is not detrimental to cash crop production.

Although the likelihood estimate of OFFARM was fairly strongly significant ($P<0.05$), the positive sign was not expected *a priori*. It had been hypothesised that farmers with off-farm employment would buy rather than produce Napier on their farms as having off-farm employment would increase their effective demand for goods and/or services that are not available from the farm. This finding may be explained by the fact that farmers with off-farm employment may use the income earned outside the farm to purchase dairy cattle. If this is the case, the likelihood of such farmers adopting Napier grass could then be high as Napier forms a major component in smallholder dairying.

The negative sign on the fairly weak but statistically significant ($P<0.1$) coefficient on MLKPRICE was also unexpected *a priori*. Production theory indicates that commodity prices guide producers in the allocation of scarce resources in the production process. All else being equal, producers will search for more productive methods of generating a larger marketed output for a commodity whose price has increased (Odhiambo, 1998). In this study, the negative sign on MLKPRICE indicates that farmers in the sample would shy away from growing Napier grass when the price of milk increases. This observation may be explained by the income effect of a price change in micro-economic theory. All else being equal, an increase in milk price may cause farm income to rise; the farmer may respond to this by seeking for alternative feeds such as purchased fodder and commercial feeds in order to release his/her land to other farm enterprises. The observed tendency of Kiambu farmers to withdraw from on-farm production of Napier grass with increase in the price of milk seems to highlight the problem of land scarcity in the district. This study found average land sizes of about one hectare per household (see section 4.1).

The coefficient on COOPMEMB was fairly significant ($P<0.05$) and had the hypothesised positive sign. Owango *et al.* (1997) have shown that dairy co-operatives provide one of the major and most stable milk outlets for dairy produce in the highland districts of Kenya. Although their core function is to purchase milk from dairy farmers, the co-operatives also supply dairy inputs such (feed concentrates and drugs), provide technical support (AI and veterinary services) and credit and loan facilities (Ombui *et al.*, 1996). Some of the dairy co-operatives demand that farmers deliver a minimum quantity of milk each month to qualify for a co-operative loan. These factors may have led to an increased demand for dairy cattle fodder, the supply of which could have been met by adopting the high biomass yielding Napier grass.

The rest of the variables in the probit model did not influence likelihood of farmers adopting the Napier technology. These variables included years of farming experience (YRSEXP), the sex of the household head (GENDER), land size (TOTLAND), tropical livestock units of cattle (TLUCAT), and extension advice (EXTADV). The lack of effect of TOTLAND on the probability of adoption of Napier grass is particularly surprising given that land is scarce in Kiambu district whereas Napier grass is a land saving technology.

Table 4.16: Maximum likelihood estimates and the marginal effects of factors influencing the probability of adoption of Napier grass in smallholder dairying in Kiambu district

	Maximum likelihood estimate			Marginal effects		
Variable	Coeff	Std error	t-ratio	Coeff	Std error	t-ratio
Intercept	0.65	0.76	0.87	0.19	0.21	0.87
EDUC	0.05*	0.03	1.64	0.01*	0.00	1.65
YRSEXP	0.01	0.01	1.24	0.00	0.00	1.24
GENDER	-0.26	0.26	-1.03	-0.08	0.07	-1.03
ZON1	0.93**	0.38	2.43	0.27**	0.11	2.50
ZON2	0.32	0.25	1.27	0.09	0.07	1.27
TOTLAND	0.03	0.05	0.66	0.00	0.01	0.66
OFFARM	0.52**	0.25	2.09	0.15**	0.07	2.11
TLUCAT	0.17	0.13	1.35	0.05	0.04	1.34
MLKPRICE	-0.08*	0.47	-1.76	-0.02*	0.01	-1.75
COOPMEMB	0.36**	0.21	1.75	0.34**	0.20	1.73
EXTADV	-0.31	0.23	-1.38	-0.09	0.07	-1.38

Log likelihood function (lnL) = -93.82
Log likelihood function (lnL_o) = -228.82
Likelihood ratio index = 0.59
Model size = 194 observations

Source: MoALDM/KARI/ILRI Survey, 1996
** and * = significance at 5% and 10% levels respectively

4.3.2 Factors influencing the level of adoption of Napier grass

The factors that influence the farmers' decision to grow more Napier grass given that the farmer was already a Napier grass grower were evaluated using the truncated model. The goodness-of-fit measure of 0.53 indicates that the model explains over 50% of the total variation in the observed data. From Table 4.17, EDUC, YRSEXP, ZON1, TOTLAND, TLUCAT and EXTADV were statistically significant in explaining the level of adoption of the Napier technology among the study farmers. Apart from EDUC which had a negative sign, all the other significant variables had positive signs.

Although the number of years of formal education of the household head had a positive impact on the probability of adoption of the Napier technology (Table 4.16), it had a negative influence on the level of adoption. This finding suggests that with more formal education farmers would tend to reduce the amount of land devoted to Napier if one is already an adopter. Although this observation was not expected *a priori*, this tendency can be attributed to a number of reasons: first, a majority of Kenyans with more formal education (secondary school level and above) usually get 'white collar jobs' in either government or private sectors. A majority of these people do not therefore regard agriculture (and particularly dairying) as an important source of income. Thus, even though some of them may have a few dairy cattle in their rural homes, the aim is not to maximise dairy production. Second, the income earned by farmers with high education may increase the demand for marketed fodders and feed concentrates such that they buy Napier rather than produce it on their farms[1]. Finally, more educated farmers may be in a better position, compared to their less educated counterparts, to assess the opportunity cost of on-farm fodder production such that the more educated farmers release their farms to other more profitable enterprises instead of growing Napier.

The coefficient on YRSEXP was also slightly significant ($P<0.1$) and had the expected positive sign. This observation agrees with human capital theory which holds that farmers become less risk averse as they gain in experience (Welch, 1979). Farming experience improves farmers' knowledge about their farms thus increasing their allocative and technical efficiency (Jamison and Lau, 1982). As already indicated on Table 4.4, most of the adopters kept high grade dairy cattle which have high feed requirements. Years of rearing cattle could therefore have influenced the farmers to expand their Napier plots in order to meet the feed requirements of their cattle.

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[1] This explanation differs from that for off-farm employment. Here we are considering the decision to grow more Napier grass given that one is already an adopter. These are two different decisions which may be influenced by a completely different set of factors as this study reveals.

Belonging to the horticulture/dairy zone had a positive and significant impact on the level of adoption of Napier among the sample farmers. Rogers and Shoemaker (1971) are cited by Ruthenberg (1985) to have argued that the adoption rate of any technology is usually (but not exclusively) influenced by its compatibility with the farming system. In this study, the positive coefficient on ZON1 probably emphasises the level of flexibility that farmers in the horticulture/dairy zone have to alter their enterprise mix compared to those in either the coffee/ or tea/dairy zones. Furthermore, the lack of a cash crop in this zone could also have made farmers to resort to dairy production as an income generating activity. Ruthernberg (1985, p. 124) argues that milk produced for sale is similar to tea or coffee because it not only adds to the household income but also stabilises that income. This could have led to the observed tendency of adopters expanding the area under Napier grass to meet the forage demands for their cattle to obtain more milk.

Land size was strongly significant ($P<0.01$) and had the hypothesised positive sign. The expansion of any land-using technology is only possible if land is not constraining. In this case, farmers with big pieces of land could have had more room to expand their Napier plots compared to farmers with smaller land sizes because land was not a constraint to them. This finding concurs with those of Adesina and Baidu-Forson (1995) and Adesina and Siedi (1995) who found farm size to positively influence the level of adoption of mangrove swamp rice varieties in Burkina Faso and Guinea Bissau respectively.

With regard to the number of cattle owned by the household, the coefficient on TLUCAT was positive and strongly significant ($P<0.01$). This was expected because the number of cattle that a farmer has should dictate the amount of land devoted to fodder production in order to meet the forage requirements of his/her cattle. Thus, the results of this study indicate that the higher the number of cattle kept the higher the level of adoption of Napier among farmers in Kiambu district.

As anticipated, the extension advice on planted forages had a fairly strong (P<0.05) and positive impact on the level of adoption of the Napier technology among the study farmers. Adoption literature indicates that farmers' technology choices are based on their subjective probabilities which are dependent on their exposure to information regarding the technology (Feder *et al.*, 1985). Extension work supplies such information through individual visits, group visits and demonstration (Ruthenberg, 1985). The fact that EXTADV had a positive coefficient indicates that extension advice on planted forages led to an expansion of the area of land allocated to Napier among farmers in the study.

Of the 11 independent variables included in this model, GENDER, ZON2, OFFARM, MLKPRICE, and COOPMEMB had no significant influence on the level of adoption of Napier amongst the farmers in the study sample (Table 4.17).

Table 4.17: Maximum likelihood estimates and the marginal effects of factors influencing the level of adoption of Napier grass in smallholder dairying in Kiambu district

	Maximum likelihood estimate			Marginal effect		
Variable	Coeff	Std error	t-ratio	Coeff	Std error	t-ratio
Intercept	-1.28*	0.71	-1.80	-0.16	0.09	-1.80
EDUC	-0.04*	0.03	-1.66	-0.01	0.00	-1.66
YRSEXP	0.01*	0.01	1.95	0.00	0.00	1.95
GENDER	0.29	0.24	1.23	0.037	0.03	1.23
ZON1	0.57**	0.29	2.00	0.07	0.04	2.00
ZON2	0.07	0.24	0.30	0.01	0.03	0.30
TOTLAND	0.13***	0.03	4.19	0.02	0.00	4.19
OFFARM	0.03	0.21	0.13	0.00	0.03	0.13
TLUCAT	0.29***	0.09	3.05	0.04	0.01	3.05
MLKPRICE	-0.01	0.04	-0.22	-0.10	0.00	-0.22
COOPMEMB	0.06	0.25	0.25	0.01	0.03	0.25
EXTADV	0.56**	0.22	2.59	0.07	0.03	2.59

Log likelihood function (lnL) = -53.08
Log likelihood function (lnL_0) = -112.63
Likelihood ratio index = 0.53
Model size = 194 observations

Source: MoALDM/KARI/ILRI Survey, 1996
***, ** and * = significance at 1%, 5% and 10% levels respectively

4.3.3 Factors that jointly influence the probability and the level of adoption of Napier grass

The Tobit model evaluated factors that jointly influence both the probability and the level of adoption of Napier grass. The explanatory power of the model is 0.51 implying that the model accounts for over 50% of the total variation in the data. The model results on Table 4.18 indicate that the coefficients on YRSEXP, TOTLAND, OFFARM, TLUCAT, and COOPMEMB had a positive and significant impact on both the probability and the level of adoption of Napier grass in smallholder dairying in Kiambu district. As already indicated, the positive coefficient on YRSEXP agrees with human capital theory which holds that farmers become less risk averse as they gain in experience (Welch, *op. cit.*). With respect to the size of land owned by the household, farmers with small land sizes were expected to adopt Napier grass in a bid to overcome the land constraint even though the level of adoption, as measured by the area of land allocated to Napier, would be lower. From the results, however, land size was positive and strongly significant ($P<0.01$) in explaining both the probability and the level of adoption of Napier by farmers in the study. Having off-farm employment significantly ($P<0.1$) influenced the probability and the level of adoption of Napier grass in Kiambu district. The number of cattle owned strongly ($P<0.01$) influenced the both the probability and the level of adoption of Napier grass. This was expected because the herd size of cattle that a farmer has should not only influence his/her adoption decision but also how much land to put under Napier grass in order to meet the feed requirements of his/her animals. The positive and statistically significant ($P<0.01$) coefficient on COOPMEMB probably emphasises the importance of dairy co-operatives/farmer organisations in the diffusion of agricultural innovations.

The results of the decomposition of the total change in the expected value of NAPLAND with change in $\mathbf{x}_i$ are also shown on Table 4.18. The results suggest that an additional year of farming experience would increase the probability of adoption of Napier technology by 2.1% and increase the area under Napier by 0.025 hectares in the entire sample and 0.004 hectares among the adopters. Furthermore, for each hectare of additional land farmed, the probability of adopting the Napier technology would increase by a significant 18.8% while the area under Napier would increase by 0.222 hectares in the whole sample and 0.034 hectares among the adopters. Likewise, acquiring an additional TLU of cattle (e.g. an extra bull or a cow and a calf) would raise the probability of adopting the Napier technology by 30.5% and the area planted with Napier by 0.36 hectares and 0.054 hectares in the entire sample and among the adopters respectively. On the other hand, having off-farm employment would raise the likelihood of adoption by almost 44% and the area allocated to Napier by 0.514 hectares in the entire sample and 0.078 hectares among the adopters. Finally, being a member in a dairy co-operative/farmer organisation would increase the likelihood of a farmer adopting the Napier technology by a significant 98.7% and increase the area devoted to

Napier production by 1.16 hectares and 0.176 hectares in the sample and among the adopters respectively. The magnitude of the total change in area under Napier as a result of changes in the individual explainer variable was rather small probably because of the small land sizes owned by farmers in Kiambu district. However, the magnitude of change in the probability of adoption of Napier among the adopters was high if a farmer belonged to a dairy co-operative society/farmer organisation. This finding seems to emphasise the important role that the dairy co-operatives/farmer organisations play in the delivery of information on new agricultural technologies. It seems as if these institutions could offer alternative channels for the delivery of such information to the end-user.

Out of the 11 independent variables included in the estimated models, only GENDER and ZON2 that did not have a significant influence on the probability and the level of adoption either independently or jointly. The lack of significance of GENDER probably indicates that male headed households in Kiambu district experience a similar degree of land constraint as female headed households.

Table 4.18: Maximum likelihood estimates and the marginal effects of factors influencing the probability of adoption and the level of adoption of Napier grass in smallholder dairying in Kiambu district and the decomposition of total change in the expected value of NAPLAND

Variable	Maximum likelihood estimate	Std error	t-ratio	Total change $\delta E[y^*]/\delta x_i$	Change among adopters $F(z)\delta[Ey']/\delta x_i$	Change in probability $Ey'\delta F(z)/\delta x_i$
Intercept	-0.12	0.32	-0.38	--	--	--
EDUC	0.00	0.01	0.18	0.006	0.001	0.005
YRSEXP	0.01**	0.00	2.39	0.025	0.004	0.021
GENDER	-0.01	0.11	-0.07	-0.021	-0.003	-0.018
ZON1	0.04	0.11	0.39	0.116	0.017	0.098
ZON2	0.11	0.11	0.97	0.292	0.044	0.248
TOTLAND	0.08***	0.02	4.33	0.222	0.034	0.188
OFFARM	0.19*	0.10	1.89	0.514	0.078	0.437
TLUCAT	0.13***	0.05	2.68	0.360	0.054	0.305
MLKPRICE	-0.03	0.02	-1.32	-0.075	-0.011	-0.064
COOPMEMB	0.42***	0.14	3.00	1.16	0.176	0.987
EXTADV	0.08	0.10	0.82	0.220	0.033	0.187

Log likelihood function (lnL) = -171.73 $z = 0.72$ $F(z) = 0.76$ $f(z) = 0.31$ $\sigma = 0.59$
Log likelihood function (lnL_o) = -348.90
Likelihood ratio index = 0.51
Model size = 194 observations

Source: MoALDM/KARI/ILRI Survey, 1996
***, ** and * = significance at 1%, 5% and 10% levels respectively

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study focused on smallholder dairying in Kiambu district. The aim of the study was to assess the factors that influence farmers' decision to adopt Napier grass and to quantitatively evaluate the impact of those factors on the adoption of planted fodder. It also aimed at recommending policy interventions that may be used to enhance the adoption of planted fodders for improved dairy production in Kenya.

The study used two sets of data collected in two phases through questionnaire interviews with farmers in Kiambu district. The two data sets were subjected to descriptive and quantitative analyses using econometric models.

The results showed that 70% of the 340 agricultural households had adopted Napier at the time of the survey. The majority of adopters were males and had more land and cattle. In general, the adopters were older than the non-adopters, although this difference was not statistically significant. The adopters also kept more dairy cattle (high grade and their crosses) than the non-adopters. More adopters than non-adopters used AI to serve their cows. The milk yield for the adopters was higher than for the non-adopters. On average, the adopters obtained more income from dairy-related activities than the non-adopters. Most of the adopters were active members of dairy co-operative societies and self-help groups at the time of the survey.

Results of the descriptive analysis of the author's data indicated that a farmer's decision to adopt Napier was motivated by the need to feed the animals. Most farmers chose Napier over other grasses because of its high biomass yield. From this study, neighbours had more influence on Napier adoption than the extension workers. The neighbours also provided Napier planting material.

Various crop residues were used as a source of dairy cattle fodder in Kiambu district at the time of this study. The most commonly used crop residues included maize stover, banana pseudo-stems, sweet potato vines and kale. Farmers also gathered grass and farm weeds to supplement cultivated fodder, mainly Napier. Fodders were also sold to neighbours and on roadside markets. Napier grass and maize stover were the main fodders traded.

From the gross margin calculations, the average price of a kilo (fresh weight) of Napier grass and maize stover was Kshs 0.30 and Kshs 0.70 respectively. The calculated average gross margins for the maize and Napier enterprises were, respectively, KShs 52,666 and KShs 17,545 per hectare per year. The results of the average farm partial budget indicated that, without considering the fixed and marketing costs associated with each enterprise, farmers would obtain more returns per hectare if they produced maize rather than Napier grass for sale.

The results of the econometric analyses indicated that the probability of adoption of Napier was positively influenced by years of education for the household head, belonging to the horticulture/dairy zone, having off-farm employment, and being a member of a dairy co-operative/farmer organisation. Milk price had a negative influence of the probability of adoption amongst the sample farmers. This may be because the income effect of a milk price rise would enable farmers to purchase Napier and other feeds outside the farm. Years of farming experience of the household head, belonging to the horticulture/dairy zone, farm size, the number of cattle owned by the household, and extension advice on planted forages had a positive impact the decision to expand the area under Napier grass. On the other hand, years of formal education for the household head negatively influenced that decision. This is probably because farmers with more formal education got employment outside the farm which increased their purchasing power for marketed fodder. Furthermore, education could also have enabled them to assess the high opportunity cost of producing Napier on their farms as demonstrated in this study. The likelihood and the level of adoption of Napier were jointly positively influenced by household head's years of farming experience, land and cattle herd sizes, off-farm employment, and membership in a dairy co-operative/farmer organisation.

The disaggregation of the marginal effects of the Tobit model showed that membership in a dairy co-operative/farmer organisation had the greatest impact on the total change in the expected value of the dependent variable. It also had the greatest impact on both the probability and the level of adoption of Napier amongst the smallholder farmers in Kiambu district, probably emphasising the importance of these organisations in the diffusion of agricultural technologies.

The sex of the household head and belonging to the coffee/dairy zone had no impact on the probability and the level of adoption of Napier either jointly or independently. The lack of effect of gender on the adoption of Napier probably implies that both male and female headed households in Kiambu district face similar production constraints.

5.2 Conclusion

The qualitative analysis indicates that the adopters were more progressive and had more formal education and farm resources than the non-adopters. Furthermore, it also indicates that farmer-to-farmer exchanges could supplement extension workers' efforts in the diffusion of agricultural technologies. In the quantitative analysis, human capital factors, namely, education and farming experience, emerge as two important factors that influence farmers' decision to grow Napier and the amount of land to allocate to Napier. Although more formal education was found to reduce the area allocated to Napier grass among the study farmers, it seems that it helped them make informed decisions in this venture. The farm resources, namely, land, off-farm employment and cattle herd size also influenced farmers' decision to adopt and expand the area planted with Napier grass, as did the institutional factors, co-operative/farmer organisation membership and extension advice. Milk price, the only market factor considered in this study, had a negative influence on farmers' decision to grow Napier grass, may be because of the income effect of a price rise. It therefore seems that targeting farmers with more farm resources with a certain level education and farming experience is likely to enhance the adoption of planted fodders in other areas of Kenya. This could be achieved through the efforts of extension workers and increasing farmer-to-farmer exchanges through the existing network of dairy co-operative societies/farmer organisations in these areas.

5.3 Recommendations

From this study, the following recommendations are made:

- The important role that dairy co-operatives and farmer organisations play in the adoption of dairy technologies (in this case, Napier grass) has been demonstrated in the quantitative analysis. Therefore, the existing dairy co-operatives and farmer group organisations in the country should be strengthened and farmers should be encouraged to join and actively participate in them. If this were done, agricultural technologies could be channelled through these organisations to supplement the efforts of extension workers.

- The results of this study also suggest the use of contact farmers to facilitate the diffusion of Napier technology to their neighbours. This could be achieved through on-farm demos, farmer-to farmer collaboration and exchanges on the management of Napier grass. Thus, the extension service could consider this approach to encourage adoption of Napier in other areas of Kenya with smallholder dairy production.

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APPENDICES

APPENDIX I: Questionnaire for the author's survey (1997)

PERSONAL DETAILS
Respondent's name ____
Are you the household head? [__________] 1 = NO 2 = YES
If NO, how are you related to the household head? [__________]

Confirm the following information:
1. HOUSEHOLD HEAD DETAILS:
* Name of the household head : ____
* Education level of household head [__________]
* Farming experience of the household head [__________] Farm manager [__________]
* Income category of the household [__________]
*** or expenditures (per month) [__________]

2. FAMILY SIZE:
* Number of Children (between 0 and 21 years) living permanently in the house [__________]
* Number of adults (>22 years) living permanently in the house [__________]
Any changes? [__________] 1=NO 2=YES
Which changes? ____
Why? ____

3. FARM DETAILS:
* Land size acres: [__________] Major Crops grown: [__________] Acreage for Napier : [__________]
Acreage for maize: [__________]
Any changes? [__________] 1=NO 2=YES
Which changes? ____
Why? ____

4. LIVESTOCK DETAILS
* Number of cattle owned by the household: [__________]
** Bulls: [__________] Cows: [__________] Heifers: [__________] Male calves: [__________]
Female calves: [__________]
** Dominant breed in the herd: [__________]
Any changes? [__________] 1=NO 2=YES
Which changes? ____
Why? ____
*Average daily milk output: [__________] kg/litres (Morning) and [__________]kg/litres (evening)
* milk outlet(s): ____
* dry season milk prices: [__________] wet season milk prices: [__________]
Any changes? [__________] 1=NO 2=YES
Which changes? ____
Why? ____

Q.2. 1=don't think that it is a better feed compared to others
2=lack of planting material
3=small farm size
4=don't have cows
5=not enough labour
6=have enough of other fodders to feed the animals
7=because I don't have a sloping shamba
8=prefers to buy rather than grow
9=it doesn't do well in this area
10=Napier grass exerts competition to the food crops
11=allergic effects to both humans and cattle
12=the value is too low
13=others (specify) ______________

Q.5. 1=Before I got a dairy cow 2=After I got a dairy cow

Q.6. 1=to intensify the use of land
2= to sell
3=to feed the animal(s)
4=to stop soil erosion
5=other (specify) __________

Q.7. 1=husband
2=wife
3=husband and wife
4=husband and son
5=Wife and son
6=husband and daughter
7=Wife and daughter
8=Son
9=daughter
10=employee
11=parents
12=grandparents
13=other (specify) ____________________

Q.9. From:
1=dairy co-operative extension workers
2=extension workers from the ministry of agriculture
3=neighbor(s)
4=radio
5=read about it in a magazine/book/pamphlet
6=seminar
7=FTC
8=farmers' field day
9=observed from relatives
10=observed need to intensify use of limited land
11= others (specify) _________

Q.10. 1=it produces high forage yields
2=Napier improves the soil by eliminating pests and diseases
3=Napier conserves the soil
4=extension workers' recommendations
5=was mandatory before obtaining a grade cow co-operative
6=for sale
7=to avoid buying for mulching other crops
8=didn't know of other suitable grasses
9=to intensify the use of the land
10=other (specify) ____________________

Q.11. 1=cuttings 2=splits 3=whole cane(s) of Napier 4=Napier seeds

Q.12. From:
1=an old Napier stand in another part of the farm
2=the local livestock/agricultural extension office/ officer
3=a neighbour
4=bought the material
5=soil conservationists
6=gathered it from the river bank
7=relatives
8= other (specify)____________________

SECTION I: HISTORICAL PERSPECTIVE

GROWING OF NAPIER GRASS

1. Do you grow Napier grass? [___] 1=NO 2=YES

2. If Q. 1 is NO, why don't you grow Napier grass? [______]

3. Rank the reasons in Q.2 in order of importance
1=[___] 2=[___] 3=[___]

4. If Q. 1 is YES, when did you start growing Napier grass? [19______]

5. Was this before or after you got your first dairy cow? [______]

6. What was the primary reason for planting Napier grass? [______]

7. Whose decision was it to plant Napier grass in your farm for the first time? [______]

8. Before you planted Napier grass on the farm had you heard/learnt about it somewhere? [______] 1=NO 2=YES

9. If YES, where had you heard/learnt about it? [______]

10. Why did you choose to grow Napier grass rather than other grasses (e.g. Kikuyu grass)? [______]

11. When you first planted Napier grass what kind of planting material did you use? [______]

12. Where did you get the planting material from? [______][______][______]

Q. 13. 1=because it was the only kind available
2=it shoots faster and gives more tillers than other kinds of planting material
3=did not know of any other type of planting material
4=other (specify) ____________

Q. 14. 1= the house hold needs for food crops (eg. maize, beans, vegetables, Irish potatoes)
2= the number of animals that I have
3= the need to sell Napier grass
4= the size was dictated by availability of other inputs like manure, fertiliser, e.t.c
5= other (specify) ____________

Q.16.

Tenure:	Crop in last rotation:	Crop in the last but one rotation:
1=Freehold	1=maize	1=maize
2=Leasehold	2=old Napier	2=old Napier
3=Public (Roadside)	3=beans	3=beans
4=Communal	4=Irish potatoes	4=Irish potatoes
5=other (specify) ________	5= General food crops	5=General food crops

Location of the patch of Napier on the farm:
1=on the steep part of the farm
2=on the flat part of the farm
3=along the river bank
4=other (specify) ____________

Q. 17. 1=to stop soil erosion
2=because it was too infertile that no other crop could do well there
3=the plot is near the homestead/(cattle boma)
4=other (specify) ____________

Q. 19. 1=appearance of Napier foliage
2=its tillering ability
3=the yield level
4=age of the Napier stand
5=the age of the crop to be replaced by Napier grass
6=soil fertility
7=other (specify) ________

Q. 21. 1=Napier grass
2= maize
3=Irish potatoes
4=General food crops
5=other (specify) ____________

Q. 22. 1=nobody
2=subchief
3=local chief
4=area agricultural officer
5=owner of the farm adjacent to the road
6=other (specify) ____________

Q. 23. 1= cash payment of ____________Ksh per month/growing season/year (specify which)
2=payment in kind (specify) ____________
3=no arrangements are made
4=other (specify) ____________

Q. 24. 1=just like my own piece of land- in terms of manuring, fertilising and weeding
2=I do not apply inputs except weeding
3=only weeding and manuring is done
4=other (specify) ____________

13. Why did you choose this kind of planting material? [____]

14. What factors influenced your decision on the size of land that you allocated to Napier grass? [______][______][______]

15. Rank the reasons in Q. 14. in order of importance:

1= [____] 2=[______] 3= [______]

16. Give the following information about where you grow Napier grass:

	PATCH 1	PATCH 2	PATCH 3	PATCH 4	PATCH 5	PATCH 6
Distance (km) from homestead	[________]	[________]	[________]	[________]	[________]	[________]
Location	[________]	[________]	[________]	[________]	[________]	[________]
Size (sq M./ ft/acre)	[________]	[________]	[________]	[________]	[________]	[________]
Tenure	[________]	[________]	[________]	[________]	[________]	[________]
Year when first planted with Napier	19_______	19_______	19_______	19_______	19_______	19_______
Date of last rotation	___/19___	___/19___	___/19___	___/19___	___/19___	___/19___
Crop in last rotation	[________]	[________]	[________]	[________]	[________]	[________]
Date of the last but one rotation	___/19___	___/19___	___/19___	___/19___	___/19___	___/19___
Crop in the last but one rotation	[______]	[______]	[______]	[______]	[______]	[______]

17. Why did you decide to plant Napier grass on this particular part of the farm? [_______]

18. Do you rotate the plot of Napier grass? 1=NO 2=YES

19. When rotating the plot of Napier, what do you consider? [_______]

20. Do you crop roadside land? [_______] 1=NO 2=YES

If YES, which crops do you grow there? [_______][_______][_______][_______]

22. F[illegible] whom do you get permission to crop the roadside plot? [___]

23. What are the terms of agreement to utilise the roadside land? [_______]

24. How do you manage the roadside land? [___]

Q. 26. Gatherer:

1=husband	5=casual labourer	
2=wife	6= permanent employee	
3=son	7=General household labour	
4=daughter	8=other (specify) ____________	

Unit:

1=manload
2=womanload
3= 50 kgs sack
4=70 kgs sack
5=handcart

Q. 27. 1=Forage maize
2=Forage bananas
3=Forage legumes (eg *Desmodium, Calliandra, Leucaena*)
4=Other (specify) ________________________________

6=90 kg sack pickup
7= pickup
8= wheelbarrow
9=donkey cart
10=other (specify) __________

SECTION II: ALTERNATIVE FODDER FROM THE FARM

A. CROP RESIDUES

25. Do you use crop residues to feed your animals? [____] 1=NO 2=YES

26. If YES, which ones do you use and when do you use them?

		Long dry Jan-Mar		Long wet Mar-May		Short dry Jun-Aug		Short wet Sept-Dec	
Type of Crop residue	Gatherer	Unit	units /day	Unit	units /day	Unit	Units /day	Unit	Units /day
[____]	[____]	[____]		[____]		[____]		[____]	
[____]	[____]	[____]		[____]		[____]		[____]	
[____]	[____]	[____]		[____]		[____]		[____]	
[____]	[____]	[____]		[____]		[____]		[____]	
[____]	[____]	[____]		[____]		[____]		[____]	
[____]	[____]	[____]		[____]		[____]		[____]	
[____]	[____]	[____]		[____]		[____]		[____]	

B. OTHER PLANTED FODDER

27. Which other fodder crops **besides Napier grass** have you **planted on your farm** and what area does each occupy?

Planted fodder	Size of land under the fodder (Acres/sq. M/paces/M)
[____]	[____]
[____]	[____]
[____]	[____]
[____]	[____]
[____]	[____]
[____]	[____]
[____]	[____]

Q. 29. Gatherer:
1=husband
2=wife
3=son
4=daughter
5=permanent employee
6=casual labourer
7= other (specify) ____________________

Source:
1=homestead plot
2=other owned plot
3=rented plot

Unit:
1=man
2= woman load
3=50 kg sack
4=70 kg sack
5= 90 kg sack

Q. 33 Gatherer:
1=husband
2=wife
3=son
4=daughter
5=permanent employee
6=casual labourer
7=General household labour
8=other (specify) ______________________

Source:
1=public land (roadside)
2=school compound
3=factory compound
4=other (specify) _______________

Unit:
1=man
2=womanload
3=50 kg sack
4=60 kg sack
5=70 kg sack

6=wheelbarrow
7=hand cart
8= donkey cart
9= pickup
10=other (specify) __________

6=wheelbarrow
7=handcart
8=donkey cart
9=pickup
10=other (specify) _________

C. GATHERED FODDER FROM THE FARM

28. Do you **gather other fodder** from **your farm**? [____] 1=NO 2=YES

29. If YES, indicate which ones, when they are gathered and the quantity gathered

		Long dry: Jan-Mar			Long wet: Mar-May			Short dry: Jun-Aug			Short wet: Sept-Dec		
Type of Gathered fodder	Gatherer	Source	Unit	Units/ day	Source	Unit	Units/day	Source	Unit	Units/day	Source	Unit	Units/day
Farm weeds	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	
Cut grass	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	
Pasture		[____]	[__]		[____]	[__]		[____]			[____]	[__]	
Other (specify)	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	
	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	
	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	
	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	

D. MAIZE NEEDS

30. How much maize did you harvest last season?

________________________ 50 /70 /90 kgs bags (GREEN/DRY or UNTHRESHED/THRESHED)

31. Does the maize harvested from your farm normally satisfy the domestic maize requirements? [____] 1=NO 2=YES

SECTION III: ALTERNATIVE FODDER FROM OFF-FARM

A. GATHERED FODDER FROM OFF-FARM

32. Do you gather **other** fodder **from outside your farm**? [____] 1=NO 2=YES

33. If YES, indicate which ones, the source, when and the quantity gathered

		Long dry: Jan-Mar			Long wet: Mar-May			Short dry: Jun-Aug			Short wet: Sept-Dec		
Type of Gathered fodder	Gatherer	Source	Unit	Units/ day	Source	Unit	Units/day	Source	Unit	Units/day	Source	Unit	Units/day
Farm weeds	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	
Cut grass	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	
Pasture		[____]	[__]		[____]	[__]		[____]			[____]	[__]	
Other (specify)													
	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	
	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	
	[__]	[____]	[__]		[____]	[__]		[____]			[____]	[__]	

Q. 35. 1=have enough fodder on the farm
2=dairying is not an important enterprise to me
3=there is no market for fodder in the area
4=lack of money to buy
5=other (specify) _________

Q. 36. Seller:
1=neighbors who do not keep cattle
2=neighbors who keep cattle but have Napier/stover/grass to sell
3=roadside markets
4=traders
5=schools
6=factory
7=other (specify)________

Unit:
1=man/womanload
2=50/70/90kgs sacks
3=Donkey cart load
4=Hand cart
5=Pick-up
6=Row of ____ M
7=Square meter
8=Weelbarrow
9=Area in acres
10=Stem

Type of Contract
1=Cash & cutting Now
2=Cash Now but cutting Later (booking the plot)
3=Cutting Now & cash Later (credit)
4=Verbal booking of the plot
5= Exchange for milk
6= Exchange for manure
7= Exchange for a bull/heifer calf
8= Other (specify)_____________

B. PURCHASED FODDER

34. Do you purchase any fodder? [___] 1= NO 2=YES

35. If NO, why not? [___]

36. If YES, indicate in the table below the type of fodders bought, the unit price, when it is bought and the type of contract involved in the purchase.

	Long dry: Jan-Mar					Long wet: Mar-May					Short dry: Jun-Aug					Short wet: Sept-Dec				
Type of fodder purchased	Seller	Unit	Unit Price	Units/ Day	CNT*	Seller	Unit	Unit Price	Units/ day	CNT*	Seller	Unit	Unit Price	Units /day	CNT*	Seller	Unit	Unit Price	Units /day	CNT*
Napier grass	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]
Dry maize stover	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]
Green maize stover	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]
Grass	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]
Banana stems	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]
Other (specify)	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]
	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]	[___]	[___]			[___]

CNT* = Type of Contract

Q. 38. 1=have enough forage
2=lack of a reliable Napier market / no supply
3=lack of money to buy
4=dairying is not an important enterprise to me
5=others (specify) ________________

Q. 39. 1=season (-al availability)
2=quantity (height/biomass yield)
3=appearance of foliage/senility
4=type of contract entered into
5=type of seller (specify) ____________
6=availability of other feeds (specify) ____
7=transport cost
8= other (specify) ________________

Q. 40 1=leaf/stem ratio
2=greenness of foliage/senility
3=lack of hairiness
4=others (specify) ____________________

Q. 43. 1=have enough forage
2=lack of a reliable maize stover market / no supply of stover
3=lack of money to buy
4=stover is not a "good" feed
5=dairying is not an important enterprise to me
6=others (specify) ______________

Q. 44. 1=season (-al) availability of stover
2=quantity
3=nature of the stover-whether green or dry
4=type of contract entered into
5=availability of other feeds (specify) ________
6=other (specify) ________________

Q. 45. 1=Green stover 2=Dry stover 3=both 4=none; it depends on availability

Q. 46. Reason:
1=cost (cheaper)
2=increased feed intake
3=higher milk yield
4=dry stover makes the cow to cough
5=availability
6=other (specify)________

Q. 49. 1=lack of planting material
2=limited land size to expand the Napier plot
3= infestation of Napier by diseases (e.g. head smut)
4= infestation by pests (e.g. moles)
5=lack of enough manure
6=drought
7=Napier has led to reduced soil fertility of the land
8=I have become allergic to Napier grass
9=other (specify) ________________

Q. 50. 1= trapping the moles
2= use of chemicals on moles
3= irrigating Napier grass
4= researchers should try to develop disease/pest resistant Napier grass varieties
5= the extensionists should provide more information on how to manage Napier grass
6=other (specify)______________

BUYING OF NAPIER GRASS

37. Do you buy Napier grass? [____] 1=NO 2=YES
38. If NO, why not? [___]
39. If YES, what determines the price of Napier grass? [___]
40. When you are buying Napier, what do look for in Napier? [___]
41. Roughly, how much does a man/woman-load of Napier grass weigh?
_______________ Kgs.

BUYING OF MAIZE STOVER

42. Do you buy maize stover? [____] 1=NO 2=YES
43. If NO, why not? [___]
44. If YES, what determines the price of maize stover? [___][___][___]
45. Between green (immature and/or mature) and dry stover which one do you prefer to buy for your animals? [____]
46. Why do you prefer this type of stover? [____]
47. Roughly, how much does a man/woman-load of maize stover weigh?
_______________ Kgs (green stover)
_______________ Kgs (dry stover)

SECTION IV: PREFERENCE & CONSTRAINTS IN GROWING NAPIER GRASS

48. Between Napier and the fodders indicated below, which is better from your point of view?

		ON THE BASIS OF		
FODDER	RANK	Milk yield	Ease of processin g	Amount of refusals
Napier grass	[___]	[___]	[___]	[___]
Green maize stover	[___]	[___]	[___]	[___]
Dry maize stover	[___]	[___]	[___]	[___]
Banana stems	[___]	[___]	[___]	[___]
Sweet potato vines	[___]	[___]	[___]	[___]
Roadside grasses	[___]	[___]	[___]	[___]
Farm weeds	[___]	[___]	[___]	[___]
Tree fodders eg *Calliandra*	[___]	[___]	[___]	[___]

49. For the time that you have grown Napier grass which constraints can you cite as regards its production and processing? [____][____][____]

50. How do you think these problems can be resolved? [____][____][____]

Q.51

Sources of Labour	Unit of Labour	Sources of Fertiliser
1= HH Head	1=hour	1=coffee co-operative society
2=Adault Males (other than HH head)	2=day	2=tea co-operative society
3=Adult Females (other than HH head)	3=week	3=local shop
4=General Adults in the HH	4=month	5=Other (specify)
5=General HH labour	5=half day	
6=Children		
7=Long-term labourers		
8=Casual labourers (men)		
9=Casual labourers (female)		
10=1&8		
11=3&8		
12=1&9		
13=3&9		

Sources of planting material

1=old Napier from another part of the farm
2=from neighbours
3=from extension workers
4=from relatives
5=other (specify) __________

<u>Sources of manure</u>	<u>Unit of planting material /fertiliser /manure</u>
1=farm	1=KG
2=bought from neighbours	2=Debe
3=bought from traders	3=Man/womanload sack
	4=25 Kg sack.
	5=50 Kg sack
	6=70 Kg sack
	7=90 Kg sack
	8=Wheelbarrow
	9=Donkey cart
	10=Pickup
	11=Lorry (7-tone)
	12=tea spoon
	13= Kasuku tin(2 kg)
	14=Other (specify)

SECTION V: NAPIER PRODUCTION FACTORS

51. Indicate the activities undertaken and inputs used when growing Napier grass

		Long dry : Jan-Mar					Long wet : Mar-May					Short dry : Jun-Aug					Short wet : Sept-Dec				
Activity	Input	Source	Unit	# of units	Unit cost	Total cost	Source	Unit	# of units	Unit cost	Total cost	Source	Unit	# of units	Unit cost	Total cost	Source	Unit	# of units	Unit cost	Total cost
Land prep.	Labour	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
	Fertiliser	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
	Manure	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
Planting	Labour	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
	Planting material	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
Weeding	Labour	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
Fertilising	Fertiliser	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
	Labour	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
Manuring	Manure	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
	Labour	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
Cutting and carrying	Labour	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			
Chopping	Labour	[___]	[___]				[___]	[___]				[___]	[___]				[___]	[___]			

Q.53. 1=too expensive to buy
2=prefers to fertilise food crops rather than Napier grass
3fertilisense/poor response
4=not economical
5=others (specify) ________________

Q.54. 1=NPK
2=TSP
3=DAP
4=Urea
5=CAN
6=other (specify) ________________

Q.55. 1=recommended by the extension worker
2=is the only fertiliser available at the coffee/tea society
3=is the only fertiliser available at the local retail shop
4=is cheaper than others
5=it makes the soil to have some wetness
6=is the one I use on maize/coffee/tea
7=advice from neighbour
8=other (specify) ________________

Q.58. 1= food crops (maize/beans/potatoes/vegetables)
2= cash crops (tea/coffee/horticulture)
3= Napier

Q.59 1=it is a food crop
2=it brings in more income than dairy
3=dairy brings in more income
4=Napier sales bring in income
5=others (specify) ________________

Q.61. 1=shortage of manure
2=prefers to manure food crops rather than Napier
3=the Napier plot is too far from the boma
4=prefers selling the manure to applying it on Napier
5=others (specify) ________________

Q.62.

Type of manure:	Source:	Destination:
1=slurry	1=from the farm	1=Napier
2= boma manure	2=bought off-farm	2=maize/beansinter-cropp
3= composted manure	3=borrowed from the neighbour	3=vegetables (kales &cabbages)
4=poultry waste	4=given by a close relative	4=seedlings
5=slaughter house manure	5=other (specify) ________	5=Irish potatoes
6=other (specify) ________		6=other (specify) ________

Q.63

Type of manure:	Unit:	Terms of trade
1=slurry	1=Wheelbarrow	1=cash on delivery
2= boma manure	2=Debe	2=bartering manure for milk
3= composted manure	3=70 kg sack	3=bartering manure for Napier
4=sifted poultry waste	4=90 kg sack	4= bartering manure for green maize stover
5=unsifted poultry waste	5=pickup	5= bartering manure for dry maize stover
6=slaughter house manure	6=lorry	6= other (specify) ________
7=other (specify) ________	7=donkey cart-load	
	8=other (specify) ________	

FERTILIZING (USE OF INORGANIC FERTILIZERS):

52. Do you apply fertiliser to your Napier? 1=NO 2=YES

53. If NO, why not? [___] [___] [___]

54. If YES, what kind of fertiliser do you apply on the Napier? [___] [___] [___]

55. Why this particular fertiliser? [___] [___] [___]

56. In one growing season, how many times do you apply fertiliser on your Napier?
________________ times.

57. When applying fertiliser, do you give priority to particular crops? [___] 1=NO 2=YES.

58. If YES, which crop(s) do you prioritise? [___] [___] [___] [___]

59. Why do you prioritise these crop(s)? [___].

MANURING (USE OF ORGANIC FERTILIZERS)

60. Do you apply manure on your Napier grass? 1=NO 2=YES.

61. If NO, why not? [___]

62. Show the type of manure that you apply on various crops on your farm:

Type of manure	Source	Destination
[__________]	[__________]	[__________]
[__________]	[__________]	[__________]
[__________]	[__________]	[__________]
[__________]	[__________]	[__________]
[__________]	[__________]	[__________]
[__________]	[__________]	[__________]

63. If the manure is bought off-farm, supply the following information.

	Source			
	Neighbour(s)	Machakos	Rift Valley	Other
Type of manure	[______]	[______]	[______]	[______]
Unit	[______]	[______]	[______]	[______]
# of units bought	[______]	[______]	[______]	[______]
Price per unit	[______]	[______]	[______]	[______]
Transport cost	[______]	[______]	[______]	[______]
Terms of trade	[______]	[______]	[______]	[______]

64. Do you use animal urine on Napier? [___] 1=NO 2=YES

Q.66. 1= food crops (maize/beans/potatoes/vegetables)
2= cash crops (tea/coffee/horticulture)
3= Napier

Q.67. 1=it is a food crop
2=it brings in more income than dairy
3=dairy brings in more income
4=Napier sales bring in income
5=others (specify) ____________________

Q.68.

Sources of Labour

1= HH Head
2=Adault Males (other than HH head)
3=Adult Females (other than HH head)
4=General Adults in the HH
5=General HH labour
6=Children
7=Long-term labourers
8=Casual labourers (men)
9=Casual labourers (female)
10=1&8
11=3&8
12=1&9
13=3&9

Unit of Labour

1=hour
2=day
3=week
4=month
5=half day

Sources of Fertiliser

1=coffee co-operative society
2=tea co-operative society
3=local shop
5=Other (specify)

Sources of Seeds:
1=local shop
2=last season's maize
3=neighbor's
4=other (specify) __________

Sources of manure

1=farm
2=bought from neighbours
3=bought from traders

Unit of seeds
1= 2kg bag
2=2kg kasuku tin
3=2kg kimbo tin
4=sack (50/70/90 kg)
5= other (specify) _____

Unit of planting material /fertiliser /manure
1=KG
2=Debe
3=Man/womanload sack
4=25 Kg sack.
5=50 Kg sack
6=70 Kg sack
7=90 Kg sack
8=Wheelbarrow
9=Donkey cart
10=Pickup
11=Lorry (7-tone)
12=tea spoon
13=2kg kasuku tin
14= Other (specify)

65. If YES, how do you apply it on Napier?

____
____
____
____
____

66. When applying manure to your crops which ones do your give priority? 1. [___] 2. [___] 3. [___]

67. Why do you prioritise this particular crop? 1. [___] 2. [___] 3. [___]

SECTION VI: MAIZE PRODUCTION FACTORS

68. Indicate the activities and inputs used when growing maize

		Long dry : Jan-Mar					Long wet : Mar-May					Short dry : Jun-Aug					Short wet : Sept-Dec				
Activity	Input	Source	Qty	Unit	Unit cost	Total cost	Source	Qty	Unit	Unit cost	Total cost	Source	Qty	Unit	Unit cost	Total cost	Source	Qty	Unit	Unit cost	Total cost
Land prep.	Labour	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
	Fertiliser	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
	Manure	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
Planting	Labour	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
	Seeds	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
Weeding	Labour	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
Fertilising	Fertiliser	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
	Labour	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
Manuring	Manure	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
	Labour	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
Thinning	Labour	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
Leaves stripping	Labour	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		
Harvesting	Labour	[__]		[__]			[__]		[__]			[__]		[__]			[__]		[__]		

Q. 69. 1=the high demand for Napier in the area
2=high price of Napier grass in the area
3=had cows but sold them
4=had cows which later died
5=soil conservation
6=other (specify) ______________________

Q. 70

Source	Unit	Napier outlet	Type of Contract
1=Plot 1	1=Donkey cart-load	1=Dairy farmers	1=Cash Now & cutting Now
2=Plot 2	2=Hand cart	2=Middlemen (brokers)	2=Cash Now & cutting Later
3=Plot 3	3=Pick-up	3=Sellers at roadside markets	3=Cutting Now & cash Later
4=Plot 4	4=50M length row	4=Others (specify) _____	4=Exchange for milk
5=Plot 5	5=Area (acres)		5=Exchange for manure
6=Plot 6	6=Wheelbarrow		6=Exchange for a calf
	7=Woman/Man-load		7=Exchange for weeding
			8=Others (specify) ______

Q. 72. 1=availability of Napier during the season
2=availability of other fodder during the season
3=height/size
4=other (specify) ______________________

Q. 73. 1=husband
2=wife
3=parents
4=son
5=daughter

Q. 74. 1=buyers come and purchase at the farm
2=Napier is cut from the farm and taken to the roadside for sale
3=Napier is cut from the farm and transported to the market centre for sale
4=other (specify) ______________________

Q. 75. 1=nothing specific
2=height/size/quantity
3=lack of hairiness
4=age of Napier
5=foliage colour (green or otherwise)
6=other (specify) ______________________

SECTION VII: MARKET FOR NAPIER GRASS

69. What motivated you to start growing Napier grass for sale? [___]

70. In the table below, indicate when you sell Napier grass, the buyers and the payment arrangements:

	PERIOD			
Sales	Long dry Jan-Mar	Long wet Mar-May	Short dry Jun-Aug	Short wet Sept-Dec
Source	[_______]	[_______]	[_______]	[_______]
Unit of sale	[_______]	[_______]	[_______]	[_______]
Unit Price	[_______]	[_______]	[_______]	[_______]
# of units sold	[_______]	[_______]	[_______]	[_______]
Total sales	[_______]	[_______]	[_______]	[_______]
Outlet	[_______]	[_______]	[_______]	[_______]
Contract	[_______]	[_______]	[_______]	[_______]

71. Is there price variation within a growing season (either wet or dry season)? [___] 1=NO 2=YES

72. If YES, what does the price variation depend on? [___]

73. Who usually sells Napier grass? [___]

74. How do you normally sell out your Napier? [___]

75. What do the buyers look for in a stand/stack of Napier grass? [___]

76. Does this preference change with seasons? [___] 1=NO 2=YES.

Q. 77. 1=the high demand for maize stover in the area
2=high price of maize stover in the area
3=had cows but sold them
4=had cows which later died
5=soil conservation
6=other (specify) ____________

Q. 78.

Source	Unit	Napier outlet	Type of Contract
1=Homestead plot	1=Area (acres)	1=Dairy farmers	1=Cash Now & cutting Now
2=Other owned plot	2=Donkey cart-load	2=Middlemen (brokers)	2=Cash Now & cutting Later
3=Rented plot	3=Hand cart	3=Sellers at roadside markets	3=Cutting Now & cash Later
4=Plot 4	4=Pick-up	4=Others (specify) _____	4=Exchange for milk
5=Plot 5	5= Woman/Man-load		5=Exchange for manure
6=Plot 6			6=Exchange for a calf
			7=Exchange for weeding
			8=Others (specify) _______

Q. 80. 1=availability of maize stover during the season
2=availability of other fodder during the season
3=height/size
4=other (specify) ____________

Q. 81. 1=husband
2=wife
3=parents
4=son
5=daughter

Q. 82. 1=buyers come and purchase at the farm
2=maize stover is cut from the farm and taken to the roadside for sale
3=maize stover is cut from the farm and transported to the market centre for sale
4=other (specify) ____________

Q. 83. 1=whether green or dry
2=nothing specific
3= other (specify) ____________

77. What motivated you to start growing maize stover for sale? [___]

78. In the table below, indicate when you sell , the buyers and the payment arrangements:

	PERIOD			
Sales	Long dry Jan-Mar	Long wet Mar-May	Short dry Jun-Aug	Short wet Sept-Dec
Source	[________]	[________]	[_______]	[_________]
Unit of sale	[________]	[________]	[_______]	[_________]
Unit Price	[________]	[________]	[_______]	[_________]
# of units sold	[________]	[________]	[_______]	[_________]
Total sales	[________]	[________]	[_______]	[_________]
Outlet	[________]	[________]	[_______]	[_________]
Contract	[________]	[________]	[_______]	[_________]

79. Is there price variation within a growing season (either wet or dry season)? [___] 1=NO 2=YES

80. If YES, what does the price variation depend on? [___]

81. Who usually sells the maize stover? [___]

82. How do you normally sell out your maize stover? [___]

83. What do the buyers look for in a stand of maize stover? [___]

84. Does this preference change with seasons? [___] 1=NO 2=YES.

1. Are you a co-operative/self-help group member? 1=NO 2= YES

2. If YES, what motivated you to be a co-operative/self-help group member?

____

____

3. Does the co-operative/self-help group offer you any agricultural inputs? 1=NO 2= YES

4. If YES, which ones?
1=Fertilizer(s) 2=Dairy feeds 3= Forage crop management advice 4=Other (specify)______________

5. [Refer to the household income class on **page 3**] Do you think your income has in any way shaped your decision to grow Napier grass? 1=NO 2=YES

6. If YES, how has it shaped your decision?

____

____

7. [Refer to the milk price on **page 3**] Has milk price influenced you to grow Napier grass?
1=NO 2=YES

8. If YES, how has it influenced your decision?

____

____

9. During the last 12 months, have you been visited by the extension workers? 1=NO 2=YES

10. If YES, how many times were you visited during the last 12 months? [______] times.

11. How has their advice influenced your decision to grow Napier grass?

____

____

Thank you very much, GOD BLESS.

Land-use system	Sub-location code/name	Total no. of households (1989 figures)	No. of households selected
Tea/dairy	1252=GATHANGARI	1127	13
	1259=KANJAI	1207	14
	1267=GATHUGU	1181	14
	1308=KAMAE	785	10
	1324=KAMBURU	1249	14
	1326=KAMUCHEGE	874	10
	1327=NYANDUMA	1403	16
	1328=GACHOIRE	999	12
Coffee/dairy	1218=KIBICHIKU	1746	21
	1221=UTHIRU	3388	31
	1239=KARURI	1182	13
	1241=GATHANGA	1214	15
	1257=RIUKI	1268	14
	1258=GIATHIEKO	795	10
	1260=KIMATHI	1287	14
	1261=NYAGA	1633	19
Horticulture/dairy	1202=LUSIGETI	1145	13
	1208=GITARU	1825	22
	1211=KERWA	2082	24
	1222=CHURA	299	10
	1223=RUKU	891	10
	1224=THIGIO	1608	19
	1227=NDIONI	372	10
	1232=NGECHA	1508	17
	TOTAL	N=31,068	n=365 (1.2%)

Pearson correlation coefficients / Prob >|p| under Ho: p=0

	EDUC	YRSEXP	GENDER	ZON1	ZON2	TOTLAND
EDUC	1.0					
	(0.0)					
YRSEXP	-0.2	1.0				
	(0.0)	(0.0)				
GENDER	0.3	-0.1	1.0			
	(0.0)	(0.0)	(0.0)			
ZON1	0.1	0.0	0.1	1.0		
	(0.2)	(0.6)	(0.3)	(0.0)		
ZON2	0.1	0.1	0.1	-0.2	1.0	
	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	
TOTLAND	-0.1	0.3	0.1	0.2	0.1	1.0
	(0.2)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)
OFFARM	0.0	-0.1	0.0	-0.0	-0.1	-0.1
	(0.4)	(0.0)	(0.7)	(0.9)	(0.1)	(0.3)
TLUCAT	0.0	0.1	0.0	0.0	0.2	0.2
	(0.6)	(0.1)	(0.8)	(0.8)	(0.0)	(0.0)
MLKPRICE	0.1	-0.0	-0.1	-0.1	0.1	-0.0
	(0.4)	(0.6)	(0.4)	(0.4)	(0.4)	(0.9)
COOPMEMB	0.0	0.1	0.1	0.1	0.1	0.3
	(0.4)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
EXTADV	0.1	0.0	0.1	0.1	0.1	0.2
	(0.0)	(0.4)	(0.2)	(0.2)	(0.4)	(0.0)

N.B. Figures in parentheses are P values

OFFARM	TLUCAT	MLKPRICE	COOPMEMB	EXTADV
1.0				
(0.0)				
-0.0	1.0			
(0.8)	(0.0)			
0.1	0.2	1.0		
(0.5)	(0.0)	(0.0)		
0.1	0.2	-0.2	1.0	
(0.0)	(0.0)	(0.0)	(0.0)	
0.0	0.1	0.0	0.2	1.0
(0.7)	(0.3)	(0.5)	(0.0)	(0.0)

Variable	Mean	Std. Dev.	Skew.	Kurt.	Minimum	Maximum	Cases
NAPLAND (ha)	0.1565	0.2202	2.0	7.7	0.0000	1.2150	340
EDUC (yrs)	10.0118	3.9785	-1.6	4.7	0.0000	16.0000	340
YRSEXP (yrs)	19.9315	13.5642	0.9	3.4	1.0000	63.0000	336
GENDER	0.7294	0.4449	-1.0	2.1	0.0000	1.0000	340
ZON1	0.1500	0.3576	2.0	4.8	0.0000	1.0000	340
ZON2	0.2441	0.4302	1.2	2.4	0.0000	1.0000	340
TOTLAND (ha)	1.0621	1.0475	2.5	12.0	0.0400	8.0970	340
OFFARM	0.2441	0.4302	1.2	2.4	0.0000	1.0000	340
TLUCAT (no.)	1.5765	0.9811	1.8	8.4	0.5000	7.6000	255
MLKPRICE (Kshs)	13.3472	2.3795	2.3	17.2	7.0000	30.0000	198
COOPMEMB	0.4588	0.4990	0.2	1.0	0.0000	1.0000	340
EXTADV	0.2971	0.4576	0.9	1.8	0.0000	1.0000	340