Analysis of Factors Influencing the Adoption of Dairy Technologies in Western Kenya

Stella Nabwile Makokha

A thesis submitted in fulfilment for the degree of Doctor of Philosophy in Agricultural Economics, University of Nairobi

NAIROBI

December 2005

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University

31/12/05

Stella Nabwile Makokha

This thesis has been submitted for examination with our approval as supervisors.

08/05/2006

Dr. Joseph Karugia, University of Nairobi

16/5/06

Dr. Steve Staal, ILRI

May 18, 2006.

Prof. Oluoch-Kosura, University of Nairobi

Acknowledgements

First and foremost I would like to thank God for enabling me to write this thesis. There were times when the going was tough but constant prayer and trust in God enabled me to trudge on.

I owe a great debt of gratitude to the Kenya Agricultural Research Institute (KARI), for granting me the opportunity to study. This research work would not have started without the study leave from the organisation. To my sponsors, the smallholder dairy and development project (SDP), without which this research work would have not seen the light of day.

My intellectual debt to my supervisors, Dr. J.T. Karugia, University of Nairobi, Dr. Steve Staal, ILRI, and Professor Oluoch-Kosura, University of Nairobi, is obviously large. Without their constructive comments and suggestions, the thesis would not look the way it does. They made sure the details of the survey procedure were adhered to, the relevant variables were selected, the appropriate models were used, the implications of the research included, and the required format of thesis organization was followed.

A variety of specific acknowledgements are in order; Mungai Githoro and Philip Ongili, for data entry and cleaning, David Njubi for guidance on the use of statistical packages, Pamela Ochungo for the colourful maps, Mary Njeri, Mustafa, Kioko, and Kimani for their excellent drive to the study area, all extension staff in the study area for facilitating the survey, and last but not least to all the households in the study area for willingly

giving information.

I will always be grateful to Hezekiah Muriuki and Angela Wokabi, both of the SDP, for their excellent facilitation and constant encouragement. They made sure that my program was running according to schedule and I had everything needed for my research work. I would also like to thank Daniel Kilambya, James Matata, Dr. Festus Mureithi, Dr. Beatrice Salasya, and Dr. Michael Waithaka, all from KARI, for their encouragement and concern.

I acknowledge with gratitude the encouragement, patience and ideas from my dear husband, Adu Wasike Makokha, which went into making the work bearable. He was always there to encourage me when the going was tough, and quick to point out when he thought that the thesis drafts were grossly inadequate in some aspects. To our children, Wakutuvi, Sunguti, and Nabalayo-Mukonja, for their patience, and whose welfare was sometimes lowered by the externalities of my research work.

Dedication

This thesis is a dedication to my late father Adriano L .W. Makokha, may God rest his soul in eternal peace, and to my mother, Mary Nasimiyu.

Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

AHA	Animal Health Assistants
ADC	Agricultural Development Corporation
AI	Artificial Insemination
CVM	Contingent Valuation Method
CJ	Conjoint
DC	Developed countries
DRCP	Dairy Cattle research Project
ECF	East Coast Fever
FAO	Food and Agriculture Organisation
FFS	Farmer Field Schools
GDP	Gross Domestic Product
GIS	Geographical Information Systems
GPS	Global Positioning System
IDB	Improved Dairy Breeds
ILRI	International Livestock Research Institute
IID	Identically and Independent Normal Distribution
KARI	Kenya Agricultural Research Institute
KCC	Kenya Cooperative Creameries
Km^2	Square Kilometre
LDP	Livestock Development Project
LDC	Less Developed Countries
LR	Likelihood Ratio
MLE	Maximum Likelihood Estimate
MRS	Marginal Rate of Substitution
MT	Metric tonnes
MOSD	Market oriented smallholder dairy
N	Nitrogen
NGO	Non-Governmental Organisation
NDDP	National Dairy Development Programme

OLS	Ordinary Least Squares
OPM	Ordered Probit Model
P	Phosphorous
PC	Principal Component
PPE	Precipitation over Evapo-transpiration
PRA	Participatory Rural Appraisal
SDP	The Smallholder Dairy Development Project
SPSS	Statistical Package for Social Scientists
RP	Revealed Preference
SP	Stated Preference
SSA	Sub-Saharan Africa
KARI	Kenya Agricultural Research Institute
WHO	World Health Organisation
WTA	Willingness To Accept
WTP	Willingness To Pay

Abstract

The necessity to improve dairy production in the less developed countries (LDCs) exists, and the Government of Kenya has recognised this as evidenced by its efforts in restructuring the dairy sector. The sector contributes substantially to the country's gross domestic product (GDP). Studies have shown that with the dairy sector restructure, smallholder farmers stand to benefit from dairy more than from other farming enterprises. However spatial differences in the rates of adoption of dairy technologies, in the face of the available opportunities, in part reflect the existence of impediments to dairy development in some parts of the country.

Western Kenya, one of the country's poorest areas, has shown low milk production levels, yet it has a high potential for dairy farming, hence the need to analyse factors contributing to the low production levels in the area. The study area consisted of seven districts: Bungoma, Kakamega, Vihiga, Nandi, Kisii, Rachuonyo, and Nyamira. Descriptive statistics and discrete choice were the methods used for analysis. The latter involved the binary choice probit model and conjoint (CJ) analysis.

Two cross-sectional data sets were used. The first set of 1575 households across all the seven districts, was used to describe the area, and analyse the cause-effect relationships in the adoption of dairy technologies. The second data set of 630 households from four of the seven districts was used for valuation of cow attributes during the CJ valuation method. The consumer theory was used in the theoretical framework of the study.

The results from the descriptive analysis showed spatial variations in the following variables; proximity to urban areas, ethnicity, resource endowments among the male and female-headed households, priorities of the household head, disease prevalence, and adoption rates of dairy technologies. Results from the cause-effect analysis in the adoption of dairy technologies show various factors that influence adoption of dairy technologies. Apart from the land economic potential which is a main determinant in adoption, other factors were availability of extension, availability of income, land size, ethnicity, population density, experience of the household head with dairy technologies, cultural factors and gender.

With regard to cow attribute valuation, milk yield was the most important attribute, followed by feed requirement and disease resistance. That household characteristics condition valuation of cow attributes was quite evident. Education, extension, off-farm income, ethnic factor, and households that preferred the Zebu for cultural purposes were critical determinants during valuation. This causes variations in adoption rates and inefficiencies in the use of local resources.

Policy interventions should be based on the fact that local resources should be mobilised to exploit the opportunities available to develop the dairy sector. More information is needed to reverse people's attitude towards dairy, and extension services should give more information on feed resources and address cultural practices that inhibit adoption of improved dairy technologies. Women should be supported because they showed a high potential to develop dairy.

Chapter I

Introduction

1.1 Livestock Products: Global Supply and Demand

Globally, the livestock sector has seen a remarkable transformation (dubbed the livestock revolution), with the less developed countries (LDCs) experiencing a higher demand for livestock products than the developed countries (DCs) (Delgado et al., 1999). Increased income, population growth, and urbanization in the LDCs have increased demand for these products, with projected milk and meat consumption rates of 2.8% and 3.3% per year respectively, between the early 1990s and 2020. The corresponding rates for the DCs are 0.6% and 0.2% per year. This is because most DCs have reached a satiation point, while the LDCs still have a rapid increase in consumption. Consequently, people in the LDCs derive 27% of their calories, and 56% of their protein from livestock products, while the DCs have averages of 11% and 26% respectively. The income elasticity of demand can, in part explain these trends. The elasticity, which is the percentage change in the quantity of a commodity demanded arising from a percentage change in the average income of the population, is positive for livestock products in the LDCs. Therefore the livestock products may be considered a normal good in the LDCs. These products may however be inferior in the DCs, where the income elasticity of demand is negative.

Most LDCs with a rapid increase in consumption levels have had a 5.4% production growth rate per year between the early 1980s and mid-1990s, more than five times the rate in the DCs. This rate projects a 50% production of the world's meat and milk by the

LDCs by the year 2020 to meet demand (Delgado et al., 1999). Besides other gains from import substitution like saving on foreign exchange and utilization of local resources, livestock products are not easily traded. This is due to the high costs in processing, preservation and transport to consumers, therefore dairy imports compete less favourably with locally produced products (Staal and Jabbar, 2000). To cut down on these costs, countries deficit in livestock products should import feed rather than these products. Kenya should therefore increase domestic production of livestock products.

Dairy contributes 60% of the total household income in the LDCs (Delgado et al., 1999) therefore contributing substantially to livelihoods in these countries. Smallholder farmers in sub-Saharan Africa (SSA) form the bulk of livestock producers, but most of them are resource poor. Poor people are vulnerable to environmental degradation because of over-dependence on the natural resources without proper management of the resources. Better livestock management has a positive effect on the environment if managed properly. Smallholder dairy, through the use of improved technologies is one way of using the natural resources without degrading them. This can therefore be a pathway out of poverty for the resource poor small holder farmers.

1.2. The Kenyan Dairy Sector

The livestock sector is important to the Kenyan economy because it contributes 10% of the overall Gross Domestic Product (GDP), and 30% of the agricultural GDP (Omore et al., 1999). Livestock products constitute 19% of the marketed agricultural produce, and 12% of the marketed livestock products is dairy (Kenya Government, 2003). In an effort

to develop the sector, the Government of Kenya has restructured the production and marketing sectors.

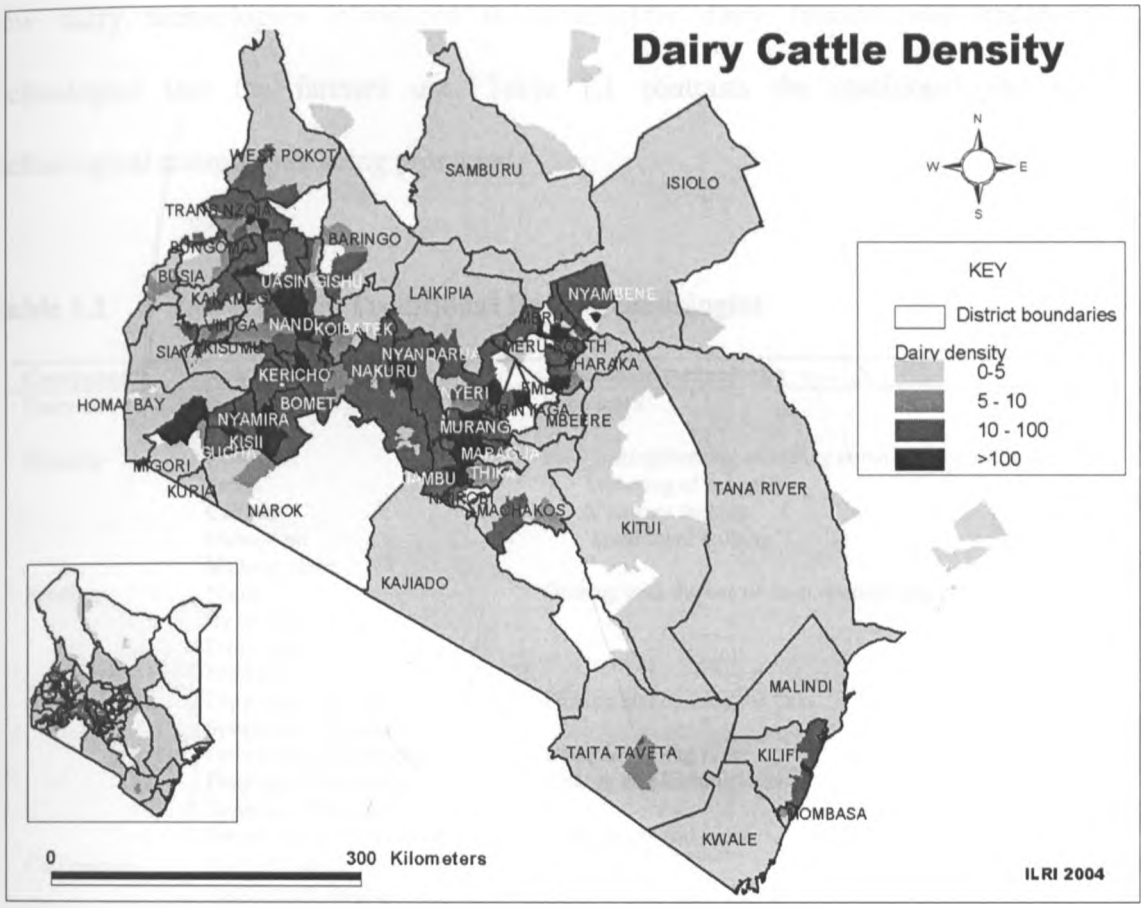
Before independence, dairy was mainly in large white-settler farms in the Kenya highlands. This changed to smallholder dairy after the Swynnerton plan of 1954. The changes can be seen in the fact that, between 1960 and 1998, the proportion of dairy cattle dropped from 88% to 23% in large-scale farms, and increased from 12% to 77% in small-scale farms (Bebe, 2003). The smallholder farms are now concentrated in the crop-dairy systems of the Kenya highlands, with an estimated dairy herd of 3 million. Most of the improved dairy breeds (IDBs) are the pure Friesian-Holstein, Ayrshire, Guernsey, Jersey, Crosses (Muriuki, 2002). In the current study, all the High Grade and Dairy Cross together were termed as the IDBs.

In the marketing sector, market liberalization in 1992 ended the monopoly of the Kenya Co-orperative Creameries (KCC), while provision of veterinary services was fully liberalised in 1994 (Omiti, 2002). The informal sector, which sells raw milk, was quite unintended following the liberalization policy, although the sector handles 80% of marketed milk (Omore, 1999).

Some parts of Kenya lag behind in dairy development. This is depicted by low adoption rates of improved dairy technologies in some areas (Omore, et al., 1999), resulting in low milk production. The study by Omore, et al. (1999) shows that Western and Nyanza Provinces produce less than 9% of the national milk output. Milk production per capita is

lowest in Western Province. Central Province, a high potential area, has a productivity of 52.8 MT per Km^2, while Nyanza, Rift Valley, and Western Provinces, which are also high potential areas, have 18.4, 8.6, and 15.2 MT per Km^2 respectively. Land intensification in Central Province is much higher than in the other provinces. This is due to a higher rate of adoption of improved dairy technologies in Central Province. The study by Omore, et al. (1999) also depicts a high price range, giving an indication of the surplus and deficit areas. Areas that have deficits depict a high demand for milk and therefore higher prices. The converse is true for deficit areas. Figure 1.1 shows dairy cattle density in Kenya.

Figure 1.1 Dairy Cattle density in Kenya



Source: Produced from the SDP data

The map shows that dairy production is concentrated in the Kenya highlands, and that only a few areas in western Kenya have more than 100 dairy cows per Km^2. Most of the IDBs are found in Central Province, where there are at least three dairy cows per household. In Kiambu District of Central Province, most smallholder farmers depend on planted fodder and purchased concentrates, and almost all households stall-feed their animals (Staal et al., 1997). Disease control in the same area is by use of vaccinations and acaricides.

In his study on adoption of dairy technologies, Batz (2000) gives a comparison of the new dairy technologies introduced to smallholder dairy farmers and traditional technologies that the farmers use. Table 1.1 contrasts the traditional and new technological components being promoted.

Table 1.1 New versus Traditional Dairy Technologies

Components	New technologies	Traditional technologies
Dairy cows	Improved Dairy cows	Zebu cows
Housing	Cow shed	Free grazing/herding including combinations with:
	Fence	Tethering of the calf
	Calf pen	Compost making
	Manure pit	Traditional milking
	Milking place	
Feeding	Napier	Grazing with the use of farm residues and by- products
	By products	
	Dairy meal	
	Minerals	
Animal health	Dipping of the cows	Picking and burning the ticks
	Spraying of the cows	
	De-worming of the cows	Using herbs and roots
	Dipping of the calves	Picking and burning ticks
	Spraying of the calves	
	De-worming of the calves	Using herbs and roots
Calf rearing	Bucket feeding	Suckling
	Concentrate feeding	

Source: Batz (2000)

The improved technologies are known to be better than the traditional ones. Housing confines cattle where manure can be collected and taken to the farm to increase soil fertility. A good milking place is built with concrete for easy cleaning in order to reduce disease build-up and milk contamination. Napier (*Pennisetum purpureum*) improves animal performance when used with concentrates in the form of dairy meal and minerals (Kariuki, 1998). Feeding of by-products like brewers waste brings to good use nutrients that would otherwise go to waste. Improved animal health technologies are more effective than the traditional ones in controlling diseases, and consequently improving

animal performance. Finally, bucket-feeding and concentrate-feeding of calves is essential for their easy management and improved performance.

1.3. The Role of Smallholder Dairy Production

After market liberalization, the informal milk market, which is the main marketing channel for smallholder dairy producers, increased producer prices by 15%, and lowered consumer prices by 25-50% of the formal market prices (Staal et al., 1997). According to Delgado et al. (1999), Kenya's household income stratum has the highest one-fifth and the lowest one-fifth deriving 38% and 61% of their income respectively from dairy. This shows that low-income households benefit from dairy more than high-income households. Dairy can employ more people on the farm and increase their incomes because, for every 100 litres of milk produced, two to three people are employed (Omore et al., 1999). According to Muriuki (2002), Kenya has about 625,000 smallholder farmers with dairy as their main source of income. About 40% of the milk produced is retained at home for consumption, thus confirming dairy, both as a source of income and household nutrition for many households.

With the rapid population growth, household land sizes are declining, while farm production needs to be increased to cater for this growth. According to Bebe (2003), 60-80% of farm income is based upon nutrient mining, and the costs of replenishing these nutrients is 32% of the average net income. Crop-dairy integration produces a nutritionally superior product (milk) in an ecologically and environmentally favourable way, where crop residues are fed to cattle, and manure is used to increase soil fertility.

Between 1980 and 1992 in the Kenya highlands, the zero-grazing technologies increased milk yield by a factor of 40.

Staal (2002) illustrates the competitiveness of dairy through a case study in two areas in Kenya showing extensive and intensive dairy. Smallholder dairy (intensive) gets above normal profits, indicating that it is quite competitive amongst other farming enterprises. Low wages, low soil fertility, and low opportunity cost of rural labour are characteristic of most East African farmers. A look at the competitiveness of smallholder dairy in such an environment exhibits higher returns to labour, higher benefits from non-dairy products through nutrient flows, and finally, more savings and accumulation of capital than from other farming enterprises. Low wages increase the value of manure because handling manure is quite labour intensive. Staal (2002) estimates the value of manure in such systems to be 30% of the value of milk produced.

Livestock products are an important source of protein and micronutrients. These nutrients remain deficient in carbohydrate-rich diets of the LDCs (Tangka et al., 2002). For instance, in Ethiopia, households with IDBs consumed 30% more calories per adult-equivalent than those without (Tangka et al., 2002). In coastal Kenya, increased income from dairy improved household nutrition (Nicholson et al., 1998) and the withdrawal of a livestock project in a village in Tanzania resulted in human nutritional problems through lower crop yields and increased poverty (Kaliba et al., 1997). Certain micro-nutrients essential for full development of cognitive skills are best obtained from animal products, including milk, and these skills may contribute to poverty alleviation.

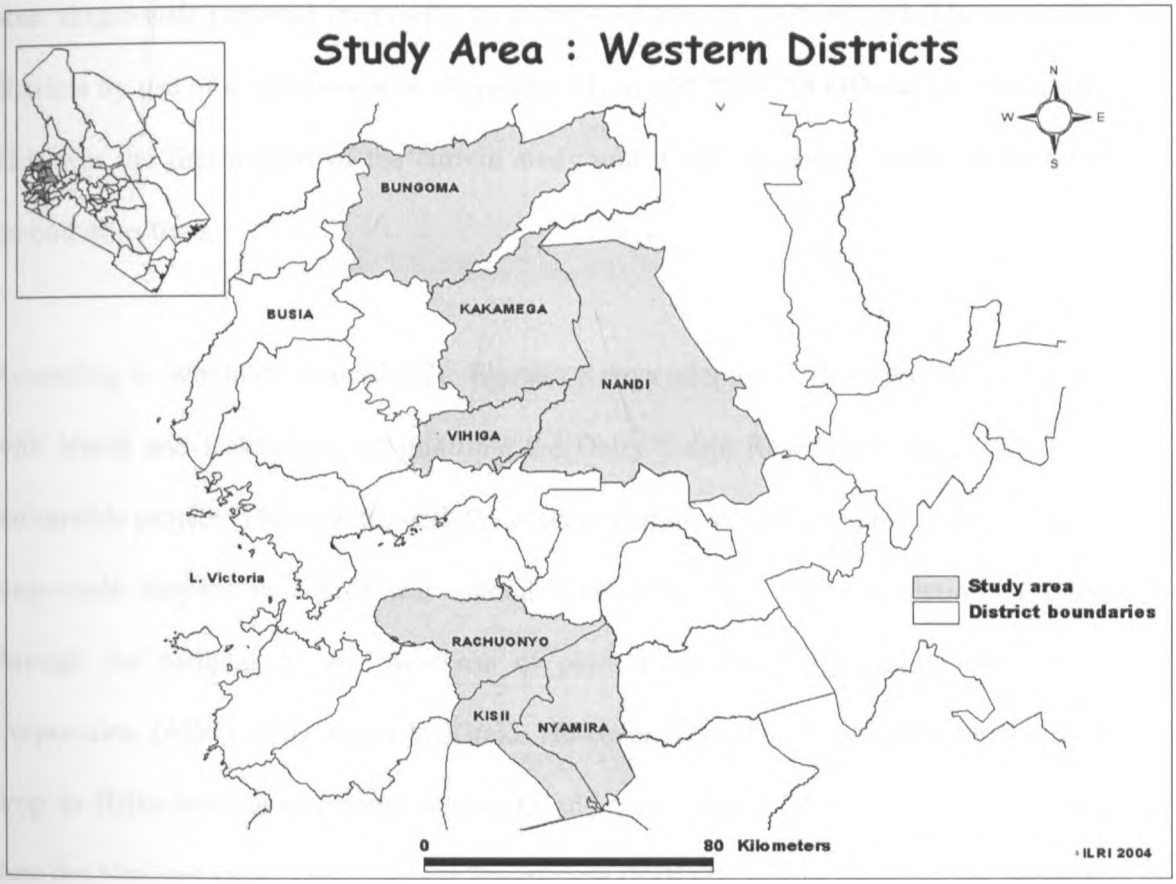
Women account for 70-80% of household food production in SSA (Brown et al., 2001), and they spend more money on food than men (Tangka et al., 2002). More involvement of women in dairy will therefore benefit households when their (women) incomes increase. In addition, studies show that women are more concerned about household nutrition than men (Brown et al., 2001), therefore they are more likely to adopt dairy technologies than the men.

Smallholder dairy farmers sell fresh raw milk that is preferred by consumers in East Africa, and that brings higher prices because of the minimal processing and packaging costs (Staal et al., 1997). The competitiveness of smallholder dairy is therefore unchallenged. However, the challenge is to make interventions that would increase intensification. Research should identify the bottlenecks in smallholder dairy production, and this is one such study.

1.4. The Study Area

The study area consists of seven districts: Bungoma, Kakamega, Nandi, Vihiga, Rachuonyo, Kisii, and Nyamira, as shown in Figure 1.2

Figure 1.2 A Map Showing the Study area



Source: Produced from SDP data

In the report by Waithaka et al. (2002), a study on characterisation of smallholder dairy households in seven districts in Western Kenya, and a historical record of dairy technologies is documented. The current study was collaboration between the Ministry of Agriculture and Rural Development, the Kenya Agricultural Research Institute (KARI),

and ILRI in the year 2000. The database captured production and marketing aspects in dairy together with the different dairy technologies available. Socio-economic factors of the households were also captured. Population density, market access, and (PPE[1]) were spatial factors used for stratification of the sampling frame, because these were key factors in determining milk production and marketing. The data set was obtained from both single-visit personal interviews on a cross-section of 1575 households across the districts by use of a questionnaire (Appendix 11-A) and from the GIS-derived variables. This was the first dataset of the current study and it was used to address the first and second objectives.

According to Waithaka et al. (2002), Western Kenya adopted IDBs in the1960s, starting with Nandi and Kakamega. At this time the Dairy Cattle Research Project (DRCP), a nationwide project (1969-1976), with the objective of disseminating dairy technologies to large-scale farmers in Kenya was started. The 1970s saw the introduction of IDBs through the national AI and purchase of cows from the Agricultural Development Corporation (ADC) dairy farms in Kitale. However the 1980s were characterized by a drop in IDBs because of disease outbreaks and lack of feed. This was about the same time the National Dairy Development Programme (NDDP), again a bilateral development project between Kenya and the Netherlands, started, with the objective to pass the DRCP technologies to small-scale farmers. The technology was a zero-grazing package that became attractive where land was scarce and farm sizes small. The NDDP started in

[1] PPE is an index that combines elevation, rainfall, and temperature into one measure. A PPE of 1 indicates that the amount of precipitation received is similar to the amount lost through evapo-transpiration, while a PPE greater than 1 means that the amount of precipitation received is greater than the amount lost through evapo-transpitration. The PPE determines the agricultural activity of land. Crop production is carried out when PPE is more than 0.5.

Kiambu, Kericho, Meru, Taita Taveta, Kilifi, and South Nyanza Districts, and then spread to a maximum of 25 districts.

Western Kenya exhibits diversity in the resources available and production systems. Apart from Nandi that is dominated by IDBs, most districts have a conspicuous presence of Zebu cattle that produce about 1 litre while the IDBs produce an average of 7 litres per cow per day. During the characterisation survey in the year 2000 (Waithaka et al., 2002), Rachuonyo District alone had 150,000 Zebu and only 3,000 High Grade cows despite more than 10 years of NDDP and the Livestock Development project (LDP) activities. The adherence to cultural values may be the reason why these households stick to the Zebu (Waithaka et al., 2002). There is high dependence on natural pastures and low use of Napier and other planted fodder, and the use of locally available concentrates is very low. The area has a potential for dairy because of the relatively larger land sizes than those in Kiambu and Meru Districts (milk surplus areas), and PPE is favourable. Population density is higher in Kisii, Nyamira, and Vihiga Districts than the rest of the districts. A high population density results in increased milk demand, and therefore an incentive to increased milk yield.

According to Waithaka et al. (2002), crop husbandry dominates in all the districts except Nandi where dairy dominates. Food crops have low yields due to low soil fertility (Jama et al., 1998; Ojiem et al., 1998; Salasya et al., 1998; Waithaka et al., 2002). The use of inorganic fertilizer and manure has been below the recommended rates. The main cash crops, especially sugarcane in Western and Nyanza Provinces, offer low and unreliable

income (Waithaka et al., 2002). Income per capita is therefore low, thus increasing the poverty level.

A person is considered absolutely poor if he/she cannot afford a recommended minimum expenditure on food, plus a minimum allowance for non-food requirement (Kenya Government, 2000). In addition, the Engel's Law states that households that allocate a larger share of their income to food are considered poor (Ritson, 1977). Using this poverty indicator, rural Nyanza leads in poverty in Kenya, with 78% of the expenditure per adult equivalent going to food, followed by rural Western (75%). Another poverty indicator is the Food Poverty Line, which the Food and Agriculture Organisation (FAO) and the World health Organisation (WHO) put at 2,250 calories per day per adult. Nyamira, Vihiga, Nandi, Bungoma and Kakamega Districts had over 50% of their respective populations below the Food Poverty Line. The Absolute Poverty Line is obtained by adding the Food Poverty Line to a minimum mean value of non-food requirements. The FAO/WHO put the Absolute Poverty Line at Ksh 1239 per adult equivalent per month for rural areas. In Kenya, rural Nyanza leads in Absolute Poverty followed by rural Coast and Western Province, by having over 55% of their population in absolute poverty. Central Province is the least poor, with only 32% of the population below the Absolute Poverty Line. Jama et al. (1998) state that about 51% of farmers in Western Kenya are resource poor and practise subsistence agriculture.

1.5. Statement of the problem

Most parts of western Kenya is home to Kenya's poorest people. The area is be-devilled

by low income from the existing crop and livestock enterprises and registers low levels of dairy development. This is inspite of indications that there is a potential for dairy development, and that dairy can reduce the level of poverty.

An indication of low dairy development in Western and Nyanza Provinces is evident in the fact that it is a milk deficit area (Waithaka et al., 2002), and that private traders get milk from Nandi to sell to these areas. In addition Western and Nyanza Provinces have had lower milk production than in the Rift Valley, Central, North Eastern, and Eastern Provinces (Omore et al., 1999).

In Western and Nyanza Provinces, low soil fertility coupled with low and unreliable income from cash crops suggest that the existing farming enterprises are inferior to dairy farming (see section 1.3), yet there is still low dairy development. The favourable PPE and abundance of fodder and by-products provide opportunities that can be utilised to promote dairy. Crop-dairy farming interaction can increase soil fertility, thus increasing overall farm performance, which can eventually increase incomes as seen in the coastal region where dairy cattle adopters at the Kenyan coastal region had 20 times more income than non-adopters (Nicholson et al., 1998).

The economic problem in the current study therefore was the existence of low and unreliable incomes from the existing crop and livestock enterprises, which has been associated with high poverty levels in western Kenya. Increased incomes may therefore lower poverty levels. Huge benefits in terms of higher farm incomes and higher

nutritional standards are lost by not developing the dairy sub-sector. The research problem was low dairy development, in spite of the potential solution the improved dairy technologies offer to low farm incomes, and in spite of the positive agro-climatic and market conditions in most parts of the study area. Central to empirical investigation was the identification of constraints to adoption of dairy technologies, and consequently the suggestion of solutions to overcome the constraints, to facilitate increased adoption of the technologies.

1.6. Objectives

1.6.1. Overall objective

The principal objective was to analyse the factors contributing to low adoption of dairy technologies in western Kenya, and to suggest ways of increasing adoption rates of the dairy technologies.

1.6.2. Specific objectives

1. To describe the household characteristics and establish the adoption patterns of dairy technologies.
2. To determine the effect of farm, farmer, institutional and spatial factors on adoption of dairy technologies.

   The Null hypothesis: The farm, farmer, institutional and spatial factors do not influence adoption of dairy technologies.
3. To determine the value households attach to the different characteristics/attributes of the dairy cow, and how this valuation is influenced by farm, farmer, institutional, and spatial factors.

The Null hypothesis: Socio-economic factors do not influence the value that households attach to different cow attributes.

4. To suggest technical and policy interventions in order to improve uptake of improved dairy technologies.

1.7 Basic assumption

The dairy technologies were adopted or dis-adopted before the survey, while the factors thought to influence adoption were observed during the survey. The assumption is that the factors observed during the survey were linked to adoption or dis-adoption despite the time lapse. It is necessary to understand this in order to link adoption and the factors observed.

1.8 Justification for the study

The population census in the year 1999 established that Nyanza and Western Provinces had only 11% of the population in formal employment, and about 32% of the population working on the family farm. Reform programmes within the public sector increased this unemployment rate by laying off employees (Kenya Government, 2000). In addition rural areas have a low opportunity cost of labour because it is not easy to transfer agricultural labour, most of it unskilled, to other forms of employment (Ritson, 1977). The high population growth rate in Western and Nyanza Provinces, which is 2.3% and 2.5% respectively (Kenya Government, 2000), means that the composition of children in households is increasing, thus necessitating the effort to meet children's nutritional needs. Increased population pressure and high unemployment rate therefore justify the need for

adoption of technologies that increase employment, generate income and increase food security.

Opportunities to increase soil fertility in the study area exist. According to Ojiem et al. (1998), raising and maintaining soil fertility in the area requires more soil nitrogen (N) and Phosphorus (P) levels. Cattle manure is one of the major sources of N in the smallholder crop farms but the amounts of manure applied are less than half of the amount required for crop production. Manure can supplement inorganic fertilizers that are unaffordable to low-income farmers. Additional labour force is needed in crop-livestock interaction, presenting a classic case of efficient job creation.

Most parts of western Kenya have a high potential for dairy, yet preference for traditional practices in dairy is high. This situation thus presents a good basis for studying the factors hampering dairy development. High preference for the Zebu means there are attributes that households look for in cattle to meet their economic and cultural needs. This may in turn influence the uptake of IDBs. Understanding how different households value different cow attributes may explain the adoption patterns observed in the study area. This valuation exercise has vital implications on the direction of dairy research and development. The high diversity in biophysical and socio-economic characteristics in the area provides a prototype study area on how diversity influences dairy technology adoption.

1.9 Organisation of the Thesis

This thesis has five chapters. Chapter I is the introduction, which gives background information, the problem under study, together with the objectives and justification of the study. Chapter II is a review of literature on adoption studies, stated and revealed preference methods for valuation of technology attributes, and the theoretical frameworks underpinning of the studies on adoption and attribute valuation. Chapter III describes the source and nature of the data, methods used for data collection, and the empirical methods for data analysis. Chapter IV presents the results of the study, while a summary of the study, conclusions and recommendations are presented in Chapter V.

Chapter II

Literature review

2.1. Overview of Adoption Studies

Adoption of agricultural technologies in the LDCs has received a lot of attention because agriculture is the source of livelihood for a majority of their populations, and because new technology offers an opportunity to substantially increase production and income (Feder et al., 1985). A new agricultural technology increases agricultural productivity, a primary mechanism for long-run sustainability of profits without necessarily increasing food prices (Sadoulet and de Janvry, 1995). New technology overcomes the law of diminishing marginal returns for existing resources, by shifting the production function upwards, thus increasing marginal productivity. Constraints to adoption of new technologies reduce marginal productivity, therefore necessitating studies to identify such constraints. The lower than expected adoption rates in adoption of new technologies is proof that there are constraints to adoption, while spatial and temporal factors contribute to the observed differences in the adoption rates (Feder et al., 1985). Studies have been done to explain these patterns of adoption behaviour, and from these studies, knowledge to explain adoption of any technology under study is derived.

2.2. Factor Interrelationships in Technology Adoption

Feder et al. (1985) states the importance of considering theoretical relationships of factors influencing adoption of agricultural technologies before reviewing empirical findings. This is because different technologies exhibit different characteristics. Some are non-divisible, like the tractor, where the extent of adoption is either use or non-use, while

others like fertilizer, are divisible. Most agricultural technologies are introduced in packages with several components, and some households may adopt the whole package while others may choose only some components. The improved dairy technological package is one such technology. A household may adopt the IDB and neither plant Napier nor use acaricides, while another may plant Napier alone and not have the IDBs. Therefore different households may have different adoption patterns of a given technological package.

The adoption pattern of a technology, and the interrelationships of the variables used have a bearing on the type of analytical model used. Some households may be targeted for adoption while others go out to look for the technology. For instance, Nkonya et al. (1998) established simultaneity in the adoption of improved maize seed and fertilizer in Northern Tanzania, while Benedicte, (2000), in her analysis on adoption of soil conservation practices in the Dominican Republic, found that one had to be resource poor to join the project, another case of simultaneity. Irungu et al. (1999) reported a high correlation amongst income, education, and membership of co-orperatives because the technology under study (Napier production) targeted wealthy households. A broader perspective on adoption patterns is therefore necessary to reveal patterns of adoption, and inter-relationships among factors influencing adoption. In the current study, a comprehensive descriptive analysis of data from the sampled households was proposed to explore these relationships.

Site-specific studies on adoption are necessary (Feder et al., 1985; Nkonya et al., 1998;

Lapar and Pandey, 1999; Kaliba et al., 1997), because some innovations differ across socio-economic groups and over time. The factors influencing adoption operate in a complex and interactive way (Lapar and Pandey, 1999) and the explanations therefore can only be technology, spatial, and temporal-specific. Studies on adoption of dairy technologies have been done in Kenya: Batz (2000) studied adoption of dairy technologies in Meru, while Nicholson et al. (1998) documented an adoption study of the dairy technologies in the coastal region. Irungu et al. (1999) studied adoption of Napier in Kiambu. Staal et al. (2002) compared adoption of dairy technologies in the Kenya highlands by use of pooled data across Kenya. However the adoption of dairy technologies was not dealt with in detail in these studies. The current study gives details on adoption patterns and analyses the underlying factors of the observed adoption patterns.

Factors that influence adoption can be divided into technology, farm and farmer (household) characteristics, and spatial factors. Farm characteristics include size and quality of land, while farmer characteristics are age, gender, household size, farm experience, education, ethnicity, income, and labour availability. Large fixed costs of a technology may reduce the tendency to adopt (Feder et al., 1985). For instance buying an IDB is expensive, and the use of its associated technologies demands more labour and capital. In addition marketing of milk brings in constraints to marketing.

The existence of market imperfections, which include high transaction costs, credit rationing, and shallow markets is a common feature in the LDCs. The imperfections

suggest inclusion of household characteristics and resource endowment in explaining adoption decisions (Sadoulet and de Janvry, 1995; Shiferaw and Holden, 1998). High transaction costs due to poor infrastructure and asymmetric information make households use their resources to adjust to the situation, while credit rationing conditions households to use their productive assets and savings to invest. Finally shallow markets, meaning a high negative correlation between supply and output price, condition some households to be self sufficient, and not have a marketable surplus. The current study therefore included household characteristics in explaining adoption decisions made by different households.

Agriculture in the LDCs depends on the whims of nature and volatile markets, thus bringing into play various spatial factors, which include population density, market access, and agro-climatic factors. According to Staal et al. (2002), the higher the population density, the smaller the land available per household, and hence the higher the likelihood of adopting technologies that increase returns to land. Population density in the neighbourhood may also determine the extent to which public land is available for pasture. A high population density may also mean a higher access to milk markets, especially in cases where adoption rates for IDB are low. The study hypothesised that a higher population density increased the probability of adoption of dairy technologies because of increased market access and increased pressure for intensification. Population density is a proxy for market access for milk if it is established that milk is sold in the neighbourhood. If milk is sold to areas far away from the homestead, then distance becomes a proxy for market access. The hypothesis was that a higher market access increases the probability of adoption.

According to Staal et al. (2002), market access has been measured in different ways. This includes measuring the quality of the route used to a market destination in terms of; relative ease of movement of people, goods and services, the utility of market destinations based on their supply and demand attributes, and distance between the point of observation and a market destination. They state that distance is the best and simplest measure of market access. This approach uses the GIS to measure distance using road networks that connect points with specific destinations, yielding a continuous measurement of access. Distance measures are appropriate market access indicators because their effect on adoption can be quantified, they can serve as a proxy for price, and allow for testing of infrastructure policy scenarios. Distance variables also control for the existence of spatial autocorrelation, that is, a lack of independence among observations in cross-sectional data sets. Adoption of a dairy cow, for instance may be a function of spill-over effects of factors like weather, slope, and soil type from the neighbourhood. These effects lower the information content thus making parameter estimates less efficient in cases where survey variables are used without the GIS-derived variables. Thus the GIS-derived variables control for occurrence of spatial autocorrelation by capturing interactions among farmers. Using dummies for different locations, as spatial variables are quite misleading because they encompass different spatial factors consisting of the PPE, market and institutional access, and ethnic factors. The GIS-derived distance variable can be used as a proxy for milk market access if it is established that milk is not sold in the neighbourhood. If milk is sold in the neighbourhood, then distance can only be used as a proxy for access to inputs for

livestock production. The current study uses descriptive statistics to establish if distance can be used as a proxy for market access.

While farm size has been used in many studies as a proxy for economic potential, this may be misleading because there may be differences in its quality and location. Land is peculiar as a factor of production because every unit of it is different from another, and its supply is fixed (Ritson, 1977), thus making PPE a more appropriate measure for economic potential. A higher PPE was hypothesised to increase the probability of adoption of the IDBs due to the increase in pasture, water and generally offer a good environment for dairy. Studies by Kaliba et al. (1997), and by Adesina and Zinnah (1993), among others, depict farm size as a proxy for wealth/resource availability because land is positively correlated to wealth in the LDCs. In some cases, larger land sizes may mean a lower probability of adoption of some technologies (Kaliba et al., (1997), because households with a higher acreage are less likely to participate in cattle stall-feeding, leaving cattle to graze freely. Napier may be grown where land is scarce because it yields more fodder per unit of land than is available through grazed pasture (Kariuki, 1998). This also emphasises the fact that feed resources, and not land may be a constraint to adoption of IDBs, as observed by Staal et al. (2001). Thus land may be a constraint only in systems that derive fodder directly from it, and not in systems that import feed. Most parts of western Kenya are highly dependent on land for fodder. Therefore a small land size gives less crop residue, hence the need to plant fodder with a high biomass per unit area. The current study uses land size as a proxy for fodder availability, and hypothesised that households with more land (more natural pasture) reduced the probability of

adopting new dairy technologies.

Adoption of new technologies will only take place when certain factor proportions are constrained (Kuyvenhoven et al., 1998). It is therefore important to know what factors constrain the adoption of a technology. The unconstrained factors can be exploited to increase productivity. For instance an increase in labor wages relative to land rents tends to increase economies of scale in production. High wages will constrain labour supply therefore technologies to increase the economies of scale need to be introduced. In dairy production therefore, herd sizes may increase and hand milking may be replaced by milking machines. Conversely low wages relative to high land rents (because of population pressure) should encourage smallholder dairy production with increased crop-livestock interaction. Therefore a study of factors that hamper technology adoption following labour supply and land availability changes is necessary.

Lapar and Pandey (1999) and Staal et al. (1997) give an illustration of how factor proportions change farming systems (and therefore the technologies), by describing systems emerging from the influence of spatial factors. Commercial plantations emerge from low population density and high market access, while smallholder commercialised systems arise from high market access and high population density. Low market access and low population encourage subsistence with fallow periods, while low market access and high population increase land intensification, and farmers tend to be self-sufficient. Labour intensive technologies are more appropriate in the latter case. In quest for self-sufficiency in milk, dairy production will prevail in urban and peri-urban areas when

urbanisation is not accompanied by adequate development of market infrastructure to connect rural producers and urban consumers (Staal and Jabbar, 2000).

Imperfections in labour markets may force households to equate labour demand with family labour supply (Shiferaw and Holden, 1998) because there will be no hired labour. The IDBs require more labour than the Zebu, to cut and carry fodder, fetch water, and provide veterinary services. Most studies take household size as a proxy for labour supply, but this may cause ambiquity, arising from the fact that a large household may have more dependants that people who can supply labour. This increases the need to have more milk for the children's nutritional needs, the need for school-fees and other expenses, leaving no cash for investment in dairy farming (Staal et al., 2002). Caution should therefore be taken to disaggregate the household size into adult members and children, the former being a proxy for labour supply, while the latter a proxy for dependency. This is especially so in cases where children contribute very little to labour. Nicholson et al. (1998) and Irungu et al. (1999) reported a negative influence of household size on Napier production but it is not clear from the results whether the influence was due to the dependency ratio or the number of adult household members. Therefore, without segregation, the influence of household size on adoption is ambiguous. The study considered the dependency ratio, which is the ratio of the number of dependants to the number of adult household members, among the factors that influence adoption.

The influence of age on adoption could be technology or location-specific (Adesina and

Baidu-Forson, 1995), and can be taken as a composite of the effects of farming experience and the planning horizon (Lapar and Pandey, 1999). Young farmers have a longer planning horizon; therefore they should have a positive effect on adoption of long-term technologies, as was seen in Nepal, where younger farmers had a positive influence on adoption of agro-forestry (Neupane, 2000). Dairy technologies are not long-term because a dairy cow can be reared and then sold off within a shorter period of time. The current study will not look at age in the perspective of the planning horizon. Nicholson et al. (1998) reported a negative influence of age on adoption of IDBs, because older farmers had a higher risk aversion to adoption of IDB. The chronological age was taken as a proxy for risk aversion and the tendency to stick to old practices. The hypothesis was that older farmers reduced the probability of adoption because of the high risk-aversion and higher cultural values that characterises them.

To use age as a proxy for experience in dairy farming therefore, is to beg for questions of validity and reliability of the analysis. This is because different farmers have different experiences in different aspects of farming, not necessarily dairy. Experience in dairy farming was more appropriate than age because a household with experience is able to better control the risk of having high cattle mortality rates, which are between 7% and 15% in Kenya (Staal et al., 2002). Thus experience of the household head in rearing dairy was used, and it was hypothesised that more experience in dairy technologies increased the probability of adoption.

Relevant information on adoption is important especially in specialised technologies like

the IDBs. This information can come from the government, the private sector, and farmers' organisations. Studies have highlighted how other factors determine the use of this information. Lapar and Pandey (1999) and Feder et al. (1985) among other studies, single out the importance of education in adoption. It creates new interests, broadens expectations, and generates a consciousness of deprivation, thus prompting educated people to seek for ways to improve their condition. Education therefore may enhance the capacity for adoption by enabling easier access to information, reducing uncertainty, and increasing allocative efficiency. Education is particularly important where extension services (another source of information) are less intense (Feder et al., 1985). This suggests that lower education level and availability of extension services may have an interactive effect on adoption. The current study considered this interactive effect and hypothesised that education influences adoption in households that had not received extension services before. Adesina and Zinnah (1993); Baidu-Forson (1999), and Kaliba et al. (1998) reported a positive influence of extension on adoption of technologies. Adesina et al. (2000) found that farmers in farmer groups where extension services were obtained easily had a higher probability of adopting alley farming.

There is a growing body of empirical evidence showing that men in the LDCs have a higher access to resources that facilitate adoption, therefore giving them a greater productive capacity than women (Kaliba et al. 1997; Staal et al., 1997; Adesina et al., 2000; Staal et al., 2002) because of the ability to adopt capital intensive technologies like IDBs. However, Tangka et al. (2000) state that women will invest in technologies that have a positive impact to family health more than the men. In addition income controlled

by women may have a greater impact on child nutrition and health than the one controlled by men (Sadoulet and de Janvry, 1995). This therefore gives women an incentive to engage in market-oriented dairy farming for more income. From these studies the influence of gender on adoption of dairy technologies is inconclusive. In addition gender may have an interactive effect with other factors.

The interactive effect of gender and education on adoption is worth noting. Neupane (2000) found that educated males had a negative influence on adoption of agro-forestry techniques in Nepal due to out-migration for employment, while educated females had a positive influence. Thus the influence of education per se on adoption may not be conclusive. It is therefore necessary to assess the influence of, either the segregated male and female education categories, or the interaction of gender and education on adoption. The current study used an interaction variable and hypothesised that the educated male household heads in western Kenya will look for off-farm employment, and not engage in farming activities, therefore reducing the probability of adoption.

Regular income and credit are the households' most common sources of capital. Cash availability increases land and labour productivity by facilitating the introduction of new and more productive ways of converting resources into products. However a higher income may also lead to investment in more profitable off-farm enterprises. This may lower on-farm investment (Shiferaw and Holden, 1998) thus having the same effect as a higher level of education. Income could be endogenous to adoption of dairy technologies, because income may influence adoption, which may also generate higher income as in

the study by Nicholson et al. (1998). This suggests that the influence of income on adoption of dairy may depend on its importance and the development level of dairy technologies on the farm. In the current study, a descriptive analysis of the data was undertaken to establish the development level and importance of dairy in the area, in order to determine whether the enterprise generates some significant income to qualify as an endogenous factor in adoption or not.

Credit availability, either formal or informal offers an economic platform for farmers, from which they can acquire other resources. According to the New Institutional Economics, formal credit rarely meets demand in LDCs (credit rationing), thereby inhibiting market clearing in the credit market. The LDCs are characterized by imperfect knowledge, bringing about moral hazard, and consequently adverse selection of people eligible for credit (Holden et al., 1998). This results into high rates of default, therefore a disincentive to credit institutions to give loans. In addition the cost of processing small loans for many individuals is high for credit institutions. Credit markets are therefore hesitant to give loans where there is demand. These imperfections in the credit market condition households to look for other sources of capital, and it may imply that households with higher savings or productive assets will invest more (Shiferaw and Holden, 1998). Not all households without access to credit are credit-constrained. Therefore credit-constrained farmers should be identified and offered credit rather than offering only those who can provide collateral (Oluoch-Kosura and Ackello-Ogutu, 1998; Staal and Jabbar, 2000). The current study looked at the credit situation in the study area through descriptive analysis to establish whether this was a binding constraint or not in

dairy technology adoption.

Different ethnic groups have different cultural practices and beliefs that influence the ability to determine technology appropriateness. Nicholson et al. (1998) recognised the influence of the ethnic factor on adoption of IDB at the coastal Kenya, because of the different culture and beliefs of the indigenous and the migrant population. Prevalence of Zebu in some ethnic groups in western Kenya is associated with cultural practices and prestige, where herd size is more valuable than herd quality (Waithaka et al., 2002). Therefore ethnicity was hypothesised to influence adoption in the study area.

This section gives an insight of the relevant variables in the study on adoption. The subsequent section highlights the different theoretical frameworks used in adoption studies.

2.3. Adoption: The Theoretical Framework and Empirical Methods

Adesina and Zinnah (1993) and Negatu and Parikh (1999) highlight three theories underlying the adoption of new technologies. The first theory, the innovation-diffusion theory, states that a technology is transferred from its source to final users through extension systems, and its diffusion depends mainly on the personal characteristics of the potential individual user. This theory makes information the key determining factor during adoption, and assumes that new technology is already appropriate for use. However, this may not be the case in the LDCs, where end-users in certain circumstances may consider it inappropriate. The second theory, the economics constraints theory,

postulates that economic constraints are the major determinants in adoption. This theory assumes that market prices reflect the scarcity of factors, implying the existence of well-performing markets. This is also an unlikely situation in most LDCs, which are characterized by market imperfections. The third theory, the adopter perception theory, suggests that perceived attributes of innovations condition adoption behaviour. It assumes that technology characteristics, the users' agro-ecological, socio-economic, and institutional contexts play the central role in adoption. It also implies involvement of farmers in technology development with the aim of generating appropriate technologies. The last theory takes into consideration the first two theories. This theory is quite realistic for the LDCs and also the basis of the consumer theory. The theory was therefore adopted for the current study.

The traditional consumer theory is the theoretical underpinning of most adoption studies. Its basic objective is to explain how a rational consumer chooses what to consume (adopt) subject to certain constraints (Sadoulet and de Janvry, 1995). It is built on the premise that a consumer will choose a good or service from a basket of goods or services that will maximize utility. Adoption studies on the basis of the traditional consumer theory alone are not exhaustive in determining what attributes of the technology condition potential adopters to make a decision. This is because the traditional consumer theory will not measure change in utility with respect to a change in the level of a particular attribute. Adoption decisions are influenced by subjective assessments of technology attributes (Adesina and Zinnah, 1993; Baidu-Forson et al., 1997; Shiferaw and Holden, 1998). It is therefore necessary to understand the technology attributes

adopters consider appropriate. These concerns are addressed in the new consumer theory.

According to the new consumer theory, goods are not the direct objects of utility, but it is from their attributes that consumers derive utility (Sy et al., 1994; Tano et al., 2003). The assumption is that utility is linearly related to product attributes (Sy et al., 1994), and this utility can be decomposed into separate utilities (Tano et al., 2003). This gives unbiased estimates of main effects of the attributes on utility, and marginal estimation of each level of each attribute can be obtained, without joint effects (interactions) of the attributes (Mackenzie, 1993).

Both theories are complementary: The traditional theory determines the key characteristics that determine adoption of a certain bundle of goods and services, while the new consumer theory determines the salient attributes that condition the observed choice behaviour.

Given two discrete choices, i and j, the probability of choosing i over j can only occur when utility of alternative i (U_{in}) is greater than that of alternative j (U_{jn}). Therefore the probability of an individual n choosing i is denoted as:

$Pr(i) = Pr\{U_{in} \geq U_{jn}\}$, while that of choosing j is:

$Pr(j) = 1 - Pr(i)$

The utility functions, U_{in} and U_{jn} can be split into deterministic and stochastic terms as illustrated by Ben-Akiva and Lerman (1985):

$U_{in} = V_{in} + e_{in}$

$U_{jn} = V_{jn} + e_{jn}$,

The V's are the deterministic components, while e_{in} and e_{jn} are random variables.

The random variables are due to the observers' errors, thus introducing the concept of random utility in the determination of choice probabilities. Replacing U with V and e in the equation;

$Pr(i) = Pr\{U_{in} \geq U_{jn}\}$, and rearranging the components gives;

$Pr(i) = Pr\{e_{jn} - e_{in} = V_{in} - V_{jn}\}$.

Model specification is done by considering $e_{jn} - e_{in}$. The assumption that $e_{jn} - e_{in}$ are a large number of unobserved, identically and independently (IID) normal distributions, by the central limit theorem, gives the probit model. This illustration uses two choices only, although it also applies to situations where an individual needs to rank different choice sets. The probit coefficients are interpreted as; a unit increase in the independent variable leads to an increase in the predicted index, by a magnitude equivalent to the coefficient of the independent variable. For better interpretation, the coefficients are changed to marginal probabilities, where they are interpreted as effects of one unit change of the independent variable on the cumulative normal probability of the dependent variable.

The parameters for the model goodness-of-fit are the likelihood ratio (LR) statistic, the Wald chi-square statistic (becomes more relevant if robust standard errors are used), and the percentage of correct prediction of the outcome. The LR and Wald statistics are chi-square statistics used to test for the null hypothesis that each of the coefficients is equal to 0. The probit model is a maximum likelihood estimation (MLE) method that predicts the highest probability of obtaining the results, guaranteeing that the estimated probabilities lie in the 0-1 range, and that they are nonlinearly related to the explanatory variables

(Gujarati, 1995; Feder et al., 1985). The binary logit model uses the cumulative logistic function, but there is no big difference between the two because they both give similar results (Gujarati, 1995).

The binary probit (and logit) single equation model is used when the dependent variable is dichotomous and the independent variables are truly exogenous (Nicholson et al., 1998). Modifications of the models are applied depending on the nature of adoption, and whether the independent variables are exogenous or endogenously determined. The adoption pattern of a technology and factor interrelationships have a great bearing on the type of analytical model used. A system describing the joint dependence of variables dictates the use of simultaneous equation estimation (Feder et al., 1985) because estimation of such models as single equations brings about simultaneous equation bias (Koutsoyiannis, 1977). This is because the error term is not independent of the independent variables thus generating biased and inconsistent parameter estimates. To address this problem, a test for the endogenous relationship (joint dependence) of some variables was undertaken in the current study.

The Hausman specification test is one of the tests for verifying the hypothesis of null correlation for models with continuous dependent variables, while the Heckman sample selection is for discrete models. Consider the equations:

$Y^*_i = \beta' X_i + e_i$

$Y^*_j = \beta' X_j + e_j$

With $e_i \sim N(0, 1), e_j \sim N(0, 1)$

Where Y^*_i and Y^*_j are dependent variables. According to Greene (2000), if the two equations are assumed to be correlated, and Y^*_i is the equation of interest, it is only observable if Y^*_j is >0, that is, if the sample selection is from above. For instance if Y^*_j is income, the sample selected is only for an income group higher than a certain value. If Y^*_i and Y^*_j are positively correlated, then the truncation of Y^*_j pushes the distribution of Y^*_i to the right of the normal distribution function, thus reducing the error variance. The mean of the error term is no longer zero, thus making the correlation positive. Therefore Y^*_j brings about what is called the sample selection bias. If there is simultaneity, then the correlation of the two error terms is not 0, that is corr $(e_i e_j) = \rho$. The Heckman sample selection method tests this correlation. Nicholson et al. (1998) and Tangka et al. (2002) established joint dependence between dairy technologies and income, giving a justification to test for independence of some variables in the current study.

According to the new consumer theory, the underpinning theory in the method used in the current study, the utility function, as written by Sy et al. (1994), is:

$U_j = (S_{1j}, S_{2j}.....S_{gj}; Z_1, Z_2, Z_i; \ p_1, p_2.....p_g | T_g) + e$, where;

S and Z are the main effect variables representing product attributes and household characteristics, respectively,

j=1,2....m, and it stands for combinations of attributes,

g =1,2.....n, and it stands for attribute levels,

i=1.2.....;n, and it stands for different household characteristics of the individual performing the valuation, the term $P_g = S_{gj}* Z_i$ is the interaction variable between the household and product characteristics, e is a disturbance term, because only a portion of

the arguments is observed, and T_g represents the parameter estimates.

Household characteristics have to be included to cater for heterogeneity in the sample, meaning that decision makers may assign different values for the same attribute of the same alternative (Karugia, 1997). To achieve conditions for maximum utility ($\delta U(s^*)$), the first order conditions with respect to product characteristics have to be obtained, and the above equation gives:

$$\frac{\delta U(s^*)}{\delta S_g} = \frac{\delta f(.)}{\delta S_g} + \frac{\delta f(.) * \delta p_g}{\delta p_g \ \delta S_g}, \text{ where;}$$

$\frac{\delta U(s^*)}{\delta S_g}$ is the marginal utility of the gth level of product to a given individual,

$\frac{\delta f(.)}{\delta S_g}$ or V_g measures change in utility when only product attribute levels vary,

$\frac{\delta f(.)}{\delta p_g}$ or b_g measures the variations in utility associated with the changes

in the interaction term, and is a direct measure of segmentality. People with the same interaction term can be grouped into one segment, $\frac{\delta p_g}{\delta S_g}$ or Z is the individual's socio-economic background.

In terms of derivatives from the first order conditions, Z is the constraint.

The marginal utility from an individual can therefore be represented by:

$$\frac{\delta U(s^*)}{\delta S_g} = V_g + Zb_g$$

People with the same b coefficient have similar preferences. These marginal utilities arise from a change in utility following a change in the level of an attribute, other attribute levels constant.

At constant utility level, the marginal rate of substitution (MRS) for two attribute levels can be measured if all other attributes are held constant except the two attribute levels. This is the rate at which a consumer is willing to substitute one attribute for another in order to remain on the same indifference curve (Varian, 1987). Given the utility function:

$U = b_1 X_1 + b_2 X_2 + \ldots\ldots + \ldots\ldots,$

Where X_1 and X_2 are two attributes levels, while the coefficients, b_1 and b_2 are marginal utilities, constant utility means that:

$\delta U = b_1 \delta X_1 + b_2 \delta X_2 \ldots\ldots + \ldots\ldots = 0$

Rearranging the equation above gives: $\frac{\delta X_1}{\delta X_2} = -\frac{b_2}{b_1}$

Thus the negative of the ratio of the two coefficients will measure the MRS. The MRS measures the slope of the indifference curves. This is from the assumption that monotonicity of preferences prevails. Moving along the indifference curves means giving up one good for another, thus dictating a negative slope (Varian, 1987). The marginal willingness to pay (WTP) will be measured if b_1 is the coefficient of the cost of the product. When b_1 is the coefficient of the cost of a given attribute, the consumer is willing to substitute (pay) some money to obtain X_2. Positive ratios show WTP for attributes that increase utility, while negative ratios show willingness to accept (WTA) payment in order to give up a product (Gan and Luzar, 1993). This theory can easily relate to cow attribute valuation: An individual's total utility from a cow (which has different attributes) is a combination of changes in utility arising from change in each of the attributes, and changes in utility when individual characteristics change. The new consumer theory is the underlying theory in the stated preference methods described in

the next sub-section.

2.4. The Stated Preference Methods and Conjoint Analysis

In recent times, the stated preference (SP) methods have increasingly received recognition (Tano et al., 2003; Scarpa et al., 2003) because they are able to capture the value of attributes that are important, but not captured by the revealed preference (RP) methods. The SP methods are more relevant in livestock attribute valuation in the LDC's because livestock is kept for both market and non-market reasons (Scarpa et al., 2003; Adamowicz et al., 1994) and non-market values cannot be determined by the RP methods. In addition the LDC's exhibit different preferences for livestock attributes across regions, countries, communities, and production systems (Scarpa et al., 2003) thus necessitating valuation across these factors. The SP methods also reduce collinearity (Adamowicz et al., 1994) that may be present in RP data sets, making attribute effects that were previously unidentified or weakly identified in the RP methods to be identified more clearly.

The methods are called SP methods because individuals state their preferences from hypothetical choices, unlike the RP methods, which are based on actual choices observed. They are quite appropriate in judging how individuals value certain technologies. The SP methods are used to place a value to each of the attributes embodied in a technology. The SP methods are more flexible because they are hypothetical, and therefore can be used to include the range of proposed changes, which the RP methods do not encompass (Adamowicz et al., 1994).

The contingent valuation method (CVM) and conjoint methods (CJ) are some of the SP methods used in attribute valuation. The CVM is most widely used for estimating non-use values (Scarpa et al., 2003; Adamowicz et al., 1994) and it involves directly asking people how much they would be willing to pay for specific services or the amount of compensation they would be willing to accept to give up specific services. These questions are repeated, each time with a higher value until the respondent expresses no willingness to pay or accept. The CVM is called contingent valuation, because people are asked to state their WTP, contingent on a specific hypothetical scenario. However the method is inadequate in the valuation of single attributes in a multi-attribute good (Scarpa et al., 2003; Kuriyama, 1998).

Conjoint analysis, also called the decompositional method describes a broad range of techniques for estimating attribute values in a product or service. It means decomposition into marginal values of a set of individual evaluations of a designed set of multi-attribute alternatives (Casey, 2000) also called profiles. Although profiles give hypothetical technology options, they should be realistic for the respondent's conceptualisation, and not be too many to cause confusion. About 20 profiles are too many for respondents with low education (Casey, 2000). Hensher (1994) highlights the pertinent issues in CJ analysis, saying that it is critical to have a carefully thought out list of attributes because too many attributes increase the burden on respondents, yet too few reduce the predictive capability of a model. Therefore there is need to limit attributes to only those that farmers are familiar with. The attribute levels chosen should include those levels in the current

experience, and if new levels have to be included they should be within the respondent's realm. Attributes that have High, Medium and Low levels can trigger behavioral response if the levels are clearly described, and they should be between the existing and achievable levels. The relevant attributes can be obtained from literature, key informants, focus groups, or past formal surveys. Identification of attributes was achieved by using information obtained from the participatory rural appraisal (PRA) done by Waithaka et al. (2002) and from the first data set for the current study (see section 1.4).

An economic evaluation of a non-market oriented community prompts the accounting of all the reasons for raising livestock irrespective of whether the products are marketed, home consumed or maintained for later use (Ayalew et al., 2003). In the study area, reasons for rearing cattle are manifested in the multiple physical, socio-economic and cultural roles that cattle play.

To preclude collinearity between attributes, independent profiles, called orthogonal designs, are derived using an orthogonal design computer program. The orthogonal designs enhance model efficiency (Mackenzie, 1993). All possible combinations of the attribute levels give what is called a full factorial design. This design considers all the main interactions, two-way interactions and higher order interactions (Kuhfeld et al., 1994). However it is not possible to have all the profiles because the number of combinations becomes too high to have a meaningful order of preference. For example a full factorial design of five attributes, with three attributes having two levels, and two attributes with three levels gives $2^3 3^2 = 72$ possible profiles in one run. A full factorial

design will have 72! designs in order to exhaust all the possible permutations. To replace these exhaustive, but unmanageable designs, computer search algorithms are used to generate a small number of non-exhaustive designs called orthogonal designs.

Algorithms are completely defined, finite computer sets/operations/procedures that will produce a particular outcome. The algorithms use some efficiency criterion to get the efficiency designs, by selecting points/profiles from the full factorial design that increase efficiency to add to the experimental design, while deleting those that reduce efficiency. The orthogonal design with the highest efficiency is the best amongst the others. Figure 3.1 illustrates how algorithms select the points.

Figure 3.1 Illustration of how Algorithms Select Points

	H	M	L
H	*	*	*
M	*	*	*
L	*	*	*

Source: Kuhfeld et al. (1994)

H - High
M - Medium
Low - Low

Figure 3.1 shows a full factorial design of two attributes with 3 levels each. This makes a total of $3^2 = 9$ different profiles, as shown by the asterisks. From nine profiles the

algorithms will pick the one with the highest possible efficiency. The four points with bigger asterisks form the optimal orthogonal design, where the points (profiles) spread out as far as possible. Efficiency therefore tends to emphasize the corners of the design space. The algorithms find efficient designs, but may fail to find the optimal designs. All orthogonal designs form a square or rectangle, thus justifying the specific numbers of profiles found in the designs (for instance 8, 9, 16, 18, 20, 24, 27), depending on the number and level of attributes in the design matrix.

Orthogonal designs recognize main effects only and assume non-significance of interaction effects among the levels. A main effect is an outcome that has a consistent difference between levels of a factor. For instance, we would say there is a main effect for milk yield if we find a statistical difference between the ranking of the low and high milk yield levels at all levels of other attributes. An interaction effect exists when differences on one factor depend on the level of another. The main effects designs assume that individuals process information in a strictly additive way, such that there are no significant interactions between attributes (Hensher, 1994).

The SPSS computer program, which was used in the current study, uses the algorithm method to generate orthogonal main effects profiles. The attribute levels are fed directly in the orthogonal design generator to design the matrix for processing. The analysis in SPSS allows for specification of the minimum number of cases for the design. If the minimum number is not specified, the program allows for generation of the minimum number of combinations necessary for the orthogonal design. A full factorial design of

four attributes, each at three levels gives 3^4=81 profiles with all the interactions gives the following attribute effects:

Main effects:	1	2	3	4		
Two-way interactions:	12	13	14	23	24	34
Three-way interactions	123	124	234			

The design has four main effects and nine interaction effects. In general a full factorial design with three attribute levels can be written as $3^{(k)}$, where k is the number of attributes. A fractional factorial design is therefore $3^{(k-p)}$, where 3^{-p} is the fraction of the full factorial design. For example a $3^{(4-1)}$ design is a $3^{(-1)}$ fraction (or one third) of the full factorial design. The minimum orthogonal design for the $3^{(4)}$ design gives 27 profiles, also written as $3^{(4-1)}$. Blocking the profiles takes care of interaction effects (as the main effects stand on their own) and a large orthogonal design. The probability that respondents give inconsistent ranking increases as the number of profiles increases (Mackenzie, 1992; Hensher, 1994). To avoid unbiased results, blocking should have equal representations of the attribute levels (Hensher, 1994; Mackenzie, 1992). The blocking factor is treated as another factor in the design (Mackenzie, 1992; Green and Srinivasan, 1990).

A complete block design (where each profile occurs exactly the same number of times in each block) is not easily achievable in CJ analysis. A balanced incomplete block design is achievable and is the one frequently used. The following are the requirements of a balanced incomplete block design (Green, 1974):

a) Each treatment (attribute) level should appear once in each block,

b) Each attribute level should appear the same number of times in the experimental design, and

c) Every pair of treatments should occur together in the same number of blocks.

In these designs, all treatment comparisons are of the same accuracy. A balanced incomplete block design however is only possible with a symmetric orthogonal array (where all attributes have the same number of attribute levels). All the attributes used in the current study have the same number of attribute levels, thus justifying the use of the balanced incomplete block design.

Gan and Luzar (1993) describe the CJ method as an extension of the CVM, where large numbers of attributes can be included in the analysis without overwhelming the respondents, and where respondents value attributes without offering money valuations of the profiles. The strength of the CJ analysis lies in the information gained from analysing trade-offs made among product attributes that can be used to establish utility of various products. In Kenya the author has not come across any study that has used the CJ method to value cow attributes in the face of different household characteristics, to explain adoption of dairy technologies. This method is quite relevant to the Kenyan situation because heterogeneity in the households' socioeconomic profile may cause differences in attribute valuation. This enables targeted interventions on specific issues that influence adoption. For instance cultural values are paramount in livestock rearing, therefore it is important to establish how they influence valuation of particular attributes. The CJ has a vantage position in including cultural values (Scarpa et al., 2003).

According to Steenkamp et al. (1987) the CJ analysis provides a more realistic situation to the respondent than the CVM, because attributes are evaluated as combinations. The CJ methods also provide consistency of the answers given by the respondent, which improves reliability of the results. The CVM is close-ended with fewer alternatives, thus denying the respondents the chance to express a better strength of conviction (Casey, 2000). The inclusion of price as an attribute can be used to estimate the marginal utility of money, which is then used to get marginal values and WTP for other attributes (Mackenzie, 1992; and Gan and Luzar, 1993).

The WTP is based on the principle that the maximum amount of money an individual is willing to pay for a commodity is an indicator of his value for that commodity. The difference between the actual price and the maximum WTP is the consumer surplus, an externality (cost or benefit) not included in the market price. This measure is used when decisions on allocation of resources need to be made based on social (rather than private) costs and benefits. Markets allocate resources in a perfect economy, and disparity between market prices and WTP may be a measure of market imperfections, therefore a measure of allocation of resources in an economy. The WTP is related to the concept of opportunity cost (Markandya, 2000). The opportunity cost of providing a commodity is defined in terms of the value of the scarce resource that has been used to produce it. When an individual buys a product, the price paid reveals a lower bound of his WTP, while the calculated WTP reveals the upper bound. In the current study, WTP was used to value different cow attributes and also indicated the opportunity cost of rearing dairy

cattle. For instance, a high WTP for cattle with low feed requirement may reflect land scarcity, the value of the next best activity on the land, or the value of the labour used to provide fodder. The WTP across different household categories shows constraints to, or opportunities for smallholder dairy in those categories.

Measures of WTP and WTA can only be equal in a perfectly competitive environment (Markandya, 2000). Disparities in these measures mean that individuals do not value benefits and perceive costs the same way. Externalities increase the WTP/WTA gap, (List, 2004) specifically making the WTA greater than the WTP. In the current study, it was hypothesised that externalities in the form of household characteristics influenced the valuation of cow attributes. Externalities in this case can be defined as factors that distort the WTP/WTA measures.

The CJ method involves the respondents stating their preference either by choice, rating or through ranking. The choice design involves a respondent choosing from a set of alternatives, and its advantage is that it mimics the real environment best. However choice design experiments are more difficult to design than the rating and ranking methods, because they require two choice sets, one to create choice alternatives and the other to create choice sets (Casey, 2000). The most appropriate choice models for analysing choice designs are the Multinomial Probit or Multinomial Logit. The Multinomial Logit has been used by Scarpa et al. (2003) in valuing indigenous farm genetic resources in Africa, and by Karugia (1997) in his study on valuation of beef attributes in Kenya. Both studies by Scarpa et al. (2003) and Karugia (1997) compared

the SP method with the traditional hedonic (RP) method. Scarpa et al. (2003) found that the choice method was precise in estimating values for cattle traits relevant in market transactions for Maasai traders. Scarpa et al. (2003) refuted the hypothesis that pastoralists engaging in cattle trading would display a different set of economic preferences when answering hypothetical questions about cattle purchases, than they do when actually buying an animal. This showed similar underlying preferences in the SP and RP methods. Results from comparison of the RP and SP methods in the study by Karugia (1997) also showed similarity in the underlying preference structure of the two methods. A similar underlying preference of the RP and SP methods is based on the theory of the random utility approach, which is identical in both the SP and RP models (Adamowicz et al., 1994). In the current study, the results from cow attribute valuation, which were obtained by using an SP method, explained the underlying factors that determined adoption in the RP method. The RP method was used to determine the factors that influenced the final choice of dairy technologies.

The rating method is the richest response metric, giving both order and degree of preference (Hensher, 1994). Analysts select a 5 or 10-point scale to represent an underlying continuous distribution of interval scaled rates. Casey (2000) used the CJ rating method to incorporate some of the overlooked values from farmers' different agro-forestry practices in Brazil. Mackenzie (1992) used CJ rating to evaluate un-priced attributes of recreational hunting trips in Delaware, United States of America. However the method is the most demanding of all (Baidu-Forson et al., 1997; Hensher, 1994) and lacks comparability among respondents (Baidu-Forson et al., 1997).

Ranking is popular with analysts who subscribe to the view that individuals are more capable of ordering alternatives than choosing or rating (Hensher, 1994). It involves ranking profiles from the most preferred to the least. This method allows respondents to better evaluate trade-offs among multiple attributes, and facilitates consistency checks on response patterns (Casey, 2000). Cattin and Wittink (1982) describe the ranking method as easy to use, and the desire to keep the judgment task as close as possible to the consumer's behaviour is maintained. The approach reveals preference ordering efficiently, but the probability of inconsistent ranking can increase as profiles increase (Baidu-Forson et al., 1997). Baidu-Forson et al. (1997) used CJ ranking to incorporate non-monetary traits in some groundnut varieties. Tano et al. (2003) used CJ ranking to estimate farmers' preferences for cattle traits in Burkina Faso, West Africa. The current study therefore adopted the CJ ranking method.

The Ordered probit or logit are the most appropriate models for CJ rating or ranking because the dependent variable takes increasing or decreasing intensity discrete values. The Ordered probit model (OPM) was used, and it has the same assumption of cumulative normal distribution of the error term as the binary probit, except that the information is recorded with increasing preference intensities. From the decision maker's theoretical utility model (Y*), the OPM is based on the assumption of the existence of the following relationship as stated by Greene (2000);

$Y^*_i = \beta' X_i + e_i$ where;

Y^*_i is unobservable, X are observable factors which is a matrix of coded attribute levels,

household characteristics, and interaction variables of the attribute levels and household characteristics, e_i is the error term.

The interaction terms of attributes are not included in conjoint analysis because they may not increase the predictive power of the models (Baidu-Forson et al., 1997). It is assumed that utility (Y*i) is related to the observable rankings (Y's) as follows:

$Y=0$ if $Y^*=0$

$Y=1$ if $0<Y^*=a_1$

$Y=2$ if $0<Y^*=a_2$

.

.

$Y=j$ if $a_{j-1} = Y^*$

The following probabilities can be specified;

$P(Y=0) = F(a_o - \beta' X_i)$

$P(Y=1) = F(a_1 - \beta' X_i) - F(a_o - \beta' X)$

.

.

$P(Y=j) = 1-[F(a_{j-1} - \beta' X_i)]$,

Where F (.) is the cumulative distribution function of a's standard normal variable. The maximum likelihood estimates of a's (threshold parameters), and β's (marginal utilities), can be obtained from the appropriate log-likelihood function. The threshold concept is central to the economic theory of consumer behaviour, which states that a buyer ranks alternatives when utility of one alternative exceeds a threshold level of "satisfaction" (Sy et al., 1994). By the central limit theorem the threshold level is assumed to be normally distributed, meaning that the relationship between the dependent and independent variables is nonlinear. When an intercept term is included in the model, the constant is

normalized to a 0 value, and only j-1(where j is the number of discrete values of the depended variable) additional parameters are estimated with the β's. The model also assumes transitivity of preferences (Baidu-Forson et al., 1997) such that if utility from Y=4>Y=0, and that from Y=5>Y=1, then utility from Y=5>Y=0.

The ordinary least squares (OLS) has been the most commonly used model in CJ analysis, but the OPM was chosen over OLS because the OPM, a discrete choice model, solves heteroscedasticity that occurs when OLS is used to analyse discrete dependent variables. In addition the maximum likelihood estimates are consistent and asymptotically normal (Sy et al., 1994). Heteroscedasticity occurs when the error term is not identically distributed because its variance is not constant, thus inflating the standard errors. If any two successive levels are not constant the dependent variable is better analysed, not as cardinal, but as an ordinal value. For instance a rating of 8 for one bundle A and 4 for bundle B does not imply that a respondent is indifferent between bundle A and two bundles of B. The OPM removes the assumption of cardinality and the consequent assumption of equal utility distances between profiles. Unlike the OLS, the ordered probit (and logit) models take into account the ceiling and floor restrictions on models (Hensher, 1994). The OLS relates independent variables and rankings directly, but the OPM first relates the independent variables to utility, then to rankings. This means that a change in choices or rankings affects utility first, then their rankings through the threshold variables (Sy et al., 1994), a sequence that is quite consistent with the new consumer theory.

Chapter III

3.1. Research Methodology

This chapter starts by giving a summary of the three methods of analysis used in the current study, and these methods correspond to the first three objectives. The first method involved analysis by use of descriptive statistics of seven districts. The study area consisted of seven districts, which were; Bungoma, Kakamega, Vihiga, Nandi, Kisii, Nyamira, Rachuonyo. The analysis gave a general description of the area, identified adoption patterns, and highlighted the socioeconomic and institutional characteristics of the area. The second method of analysis sought to explore relationships among variables relevant in the adoption of dairy technologies. Principal component (PC) analysis was undertaken to minimise multi-collinearity amongst the relevant variables. Thereafter the Heckman procedure was performed to detect any endogenous relatiobships, and lack of correlation amongst the variables justified the use of the probit single equation method. The first and second methods used data from 1575 households spread across seven districts (see Section 1.4).

In the third method, an analysis of the importance/relevance of cow attributes and how they influence households' decisions to make the final choice of their dairy breed was done. A sub-sample of 630 households was taken from five of the seven districts. The five districts were selected on the basis of their representativeness of the area in terms of the biophysical and socio-economic characteristics. After the relevant variables were delineated through PC analysis, the CJ experiment was then undertaken. This activity involved identification of the relevant cow attributes, combination of the attribute levels

to give profiles through the experimental design and ranking the different profiles by respondents. Finally the data were analysed by use of the OPM. The subsequent sections give the conceptual framework of the study and a detailed description of the methods used.

3.2. The Conceptual Framework

Feder et al. (1985) define adoption as the mental process an individual passes through, from first hearing about an innovation to final use. Final adoption at the individual level is defined as 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. The current study used this definition of adoption. However, the household, and not the individual is considered as the relevant unit of adoption. The focus is on the household because adoption of most agricultural technologies occurs at the farm-level, and the household head is assumed to consider the household in making decisions. Adopters are the households using a particular technology, while non-adopters are those not using the technology at a particular point in time.

The household is a decision-making unit, which sets the strategy concerning the generation and use of income for consumption and production (Sadoulet and de Janvry, 1995). It can also be referred to as the group that shares the same abode or hearth. Thus all people who live and sleep in one household, and influence production and consumption decisions are termed as being in one homestead. The household entity is an addition to other economic agents (consumers, producers and the government) in the

standard microeconomic approach to the study of the behaviour of economic agents in a given environment (Sadoulet and de Janvry, 1995). In the presence of imperfect markets the household is important as an institution that internalises many transactions instead of buying all it consumes, selling all it produces, or hiring all factors of production.

The consumer theory is pervasive in the current study. This theory is used to explain how a rational consumer maximises utility subject to various constraints. All households are considered rational in their decision-making when maximising utility. In the current study, a household faces the choice of whether to adopt improved dairy technologies or the traditional livestock practices. The observed choice of a dairy technology is made through assessment of the technology attributes in the face of the household's characteristics and circumstances. A technology attribute that would reduce the households' utility lowers the probability of adoption of that technology and vice-versa. The current study also looks at how attributes in the IDBs and in the Zebu influence the final adoption of the dairy technologies observed in the study area. Various variables were conceptualised to influence the adoption process. The factors that were hypothesized to have a positive influence on adoption of dairy technologies were:
The household's experience in dairy farming, a higher education level of the household head, some ethnic groups in the study area, availability of transport and extension service, an income level of more than Ksh 5,000 per month, a lower land acreage, a PPE of more than 1, a higher population density and a shorter distance to an urban area.

3.3. Data needs and Sources

To achieve its objectives the current study required data on the type of dairy technologies available, household characteristics, spatial and institutional factors in study area. The database from SDP provided comprehensive data on all these variables. Staal et al., (1997) assembled data and characterized households in seven districts in western Kenya: Bungoma, Kakamega, Vihiga, Kisii, Rachuonyo, Nyamira, and Nandi. The database captured production and marketing aspects in dairy production. Population density, market access, and PPE were spatial factors used for stratification of the sampling frame, because these factors are key in determining milk production and marketing. The data set was obtained from both single-visit personal interviews on a cross-section of 1575 households across the districts by use of a questionnaire (Appendix 11-A) and from the GIS-derived variables.

In order to establish the values that households attached from the attributes in IDBs and the Zebu, data on how different households ranked different combinations of the attributes from both breeds were necessary. The data was collected from a sub-sample of 630 households selected by use of computer randomization. Each household was asked to rank 5 combinations of cow attributes or profiles by use of a questionnaire (Appendix 11-B).

3.4. Sampling and data collection procedure

This section describes how the first data set was obtained. By use of spatial factors for stratification of households across the seven districts, six categories of sub-locations (the

smallest administrative unit) were delineated. The spatial factors were household density within a 5 km radius, market access and PPE. The STATA statistical software was used to cluster the sub-locations according to population density, market access and PPE as shown in Table 3.1.

Table 3.1 The Sub-Locations Clustered according to Population Density, Market Access and PPE in the study area

No. of sub-locations in each cluster	Mean household density		Mean market access		Mean PPE	
	Persons per km^2	level	Time	level	index	Level
1 (one sub-location)	0	low	5 hrs	poor	1.07	high
2 (15 sub-locations)	497	high	0.2 hrs	good	0.91	medium
3 (155 sub-locations)	53	low	2 hrs	poor	0.95	medium
4 (106 sub-locations)	174	medium	0.6 hrs	good	1.07	high
5 (238 sub-locations)	61	low	0.8 hrs	medium	0.85	low
6 (154 sub-locations)	75	low	1hr	medium	1.15	high

Source: Waithaka et al. (2002)

The first two groups in Table 3.1 were dropped because they represented few sub-locations. Market access is indicated by the time taken to reach the nearest urban centre. Homogenous divisions were grouped together, and two contrasting divisions from each district were chosen to serve as the sampling frame, as shown in Table 3.2.

Table 3.2 **The Selected Divisions grouped by Market Access, PPE, and Population Density**

District	Market Access	PPE	Population density
Bungoma			
Kimilili	Low>2hrs	Medium (0.85-1)	121
Nalondo	Medium (1-2 hrs)	High (>1)	75
Kakamega			
Malava/Kabras	Medium (1-2 hrs)	Medium (0.85-1)	46
Ikolomani	High (<1hr)	High (>1)	120
Vihiga			
Emuhaya	High (<1hr)	High (>1)	188
Hamisi	High (<1hr)	High (>1)	119
Kisii			
Suneka	Medium (1-2 hrs)	Medium (0.85-1)	105
Masaba	High (<1hr)	High (>1)	89
Nyamira			
Ekerenyo	High (<1hr)	High (>1)	207
Magombo	High (<1hr)	High (>1)	96
Nandi			
Kapsabet	Medium (1-2 hrs)	High (>1)	41
Kilibwoni	Medium (1-2 hrs)	High (>1)	32
Rachuonyo			
Oyugis	Medium (1-2 hrs)	Medium (0.85-1)	61

Source: Waithaka et al. (2002)

The formula by Poate and Daplyn (1993): $n=\frac{2[zc]^2}{2d^2}$,

was used to calculate the sample size for each sub-location, where:

d is the desired difference in the sample, in this case the variability in the samples of adopters and non-adopters was chosen as 20%,

n is the required sample size,

z is the value of the confidence level from the normal distribution, chosen as 1.96,

c is the coefficient of variation, chosen as 68%. This stands for variation of the variable in the population, that is, the standard deviation divided by its mean, and its value is normally fixed between 40% and 80% (Poate and Daplyn, 1993).

Poate and Daplyn (1993) state further that this formula is normally used when comparing populations (like adopters and non-adopters), and when the direction of the expected difference is known. The formula arrives at a minimum of 89 households per stratification class. The total sample size was readjusted to cater for proportionality from the population data of the 1989 census. This was necessary in order to have a good representation of the population in the districts. The final sample size was 1,575 households, with the sample size for each district as shown in Table 3.3.

Table 3.3 The Households Surveyed by District

District	Households surveyed
Bungoma	162
Kakamega	279
Kisii	269
Nandi	123
Nyamira	250
Rachuonyo	158
Vihiga	334
Total	**1575**

Source: Staal et al. (2002)

Random transects were then drawn in each sub-location, and every fifth household along the transect was selected until the desired sample size was achieved. Each household was geo-referenced using the Global Positioning System (GPS). The research team obtained the spatial variables (distance, and population density) through several steps.

With regard to the distance variable, the topographic map sheets at a scale of 1:50,000

from the Survey of Kenya were obtained. Three classes of roads, namely; all-weather tarmac, all-weather loose surface, and earth roads only used in dry weather were digitized. The district-level road authorities provided information on recent road renovation, and all main roads were visited to update the quality attributes in the GIS. The GIS software (workstation ARC/INFO, ESRI, 1998) was used to assign a farm or facility to the nearest node or intersection in the network, where major urban areas and milk market facilities were added as nodes. The GIS software was used to calculate travel times on each section of road length and its associated travel speed. This information was then used to calculate distance. For each node on the network obtained, total distance to the two nearest urban areas, to the largest city (Nairobi), and to the nearest formal milk collection centres by least travel times on the three road types was obtained. Finally smoothly accessible surfaces for the whole study area were obtained through interpolation.

For the population density variable, the Arcview Spatial Analyst, another GIS software was used. Focal neighbourhood functions were used to evaluate the mean population density within a 5 km radius for every point in the study area. The human population density layer, which was developed at ILRI, was based on the 1989 Kenya census, and is attached to sub-location boundaries. The mean population density within a 5 km radius for every household in the study area was a proxy for milk market access because most households sold milk to neighbours. The PPE was obtained by what is called the Almanac Characterisation Tool (Staal et al., 2002). The team also collected data on household resources, land use and management practices, livestock inventory, input use,

and use of livestock and extension services. All the data were managed and coded by use of the Microsoft Excel program, then transferred to the STATA statistical program for analysis, where re-coding was done to get the relevant variables for analysis.

3.4.1. Extracting variables from principal components

The principal components (PC), in Table 1-A, Appendix 1, are important in minimizing multicollinearity amongst independent variables during regression analysis (Koutsoyiannis, 1977). Therefore some variables appearing in Tables 4.1 and 4.2 were eliminated following the PC analysis.

Multi-collinearity is the presence of linear relationships among explanatory variables, causing the parameters of explanatory variables to be indeterminate (Koutsoyiannis, 1977). It is undesirable because it may give wrong signs or cause instability in the coefficients. Unlike simple correlations that measure the relationship of two variables without regard of other variables, PC analysis takes into account many variables, and resolves them into distinct patterns of occurrence (Rumell, 1976). Simple correlations can be misleading because they cannot determine correlations between qualitative and quantitative variables, and assume that the influence of other factors is constant. The PC analysis constructs a set of new variables known as principal components that are linear combinations of the original variables. The principal components were not used to explain adoption because it would be difficult to explain how the composite factors influence adoption. The alternative was to pick variables from each PC that were not highly correlated. During PC analysis, the risk of creating the econometric problem of

omitting important variables was acknowledged, but the benefit of reducing multicollinearity was realized.

Koutsoyiannis (1997) describes the steps taken during PC analysis, which is done by first constructing a correlation table of the independent variables that will determine the first PC (PC_1). The second PC (PC_2) is obtained from a new residual correlation table, formed by removing a part of the total variation taken by PC_1. The subsequent PCs are also obtained by first getting their residual tables, and then repeating the same process. The maximum number of PCs is equal to the number of variables, and not all PCs are retained for use. Among several criteria for retaining PCs, the Kaiser's criterion (Koutsoyiannis, 1977), which retains factors with an Eigen value greater than 1, was used in the current study. This criterion captures only the largest magnitude of variations in the variables. Variables within each PC are linear combinations, therefore correlated, and the ones in different PCs are independent or orthogonal. Multicollinearity can therefore be minimized by choosing one variable from each PC. From the variables chosen, eight Eigen values were greater than 1, and Table 1-A, Appendix 1 shows correlation of different variables with the 8 PCs. The coefficients marked with an asterisk (*) are highly correlated, either negatively or positively with their respective PCs, therefore only one variable with the asterisk (*) was taken from each column. Variables taken from PC analysis are PPE, the ethnic factor, the ratio of pre-school and school-going household members to adults in the household, gender, whether households had off-farm income as the main source of income or not, distance to the main road by earth road, the income category of the household, and age of the household head. The variables that had weak

correlation with the coefficients were; education of the household head in years, current land size in acres, rank of food as the main expenditure, population density in terms of persons per $5km^2$, whether the household had IDBs 10 years[2] back or not, whether the household had planted fodder 10 years back or not, and whether the household received extension services on any topic on dairy or not. Because of their weak correlation, these variables were also included in the analysis.

3.5. The Binary Choice Probit Model

The probit model, a dichotomous choice model with 0 and 1 as the values of the dependent variable was used to investigate factors influencing adoption. A value of 1 was given for a dependent variable if adoption occurred and 0 otherwise. Various other variables entered the equation as independent variables in the binary probit analysis.

The Heckman procedure was carried out to test for any endogenous relationships between income and adoption of IDB, Napier production and the use of anti-helminthics, by estimating the income equation and each of the adoption equations simultaneously. Significance of the correlation factor would mean joint dependence of the variables, and therefore the equations should be estimated jointly. Non-significance of the correlation factor means that the equations can be estimated independently. The Heckman procedure was also applied to the equations:

(i) Adoption of Improved Dairy Breed (IDBs) = f (independent variables)

(ii) Napier Production= f (independent variables)

(iii) Use of Anti-helminthics = f (independent variables),

to test for independence in the estimation of each pair of the three models.

[2] Ten years was the time considered ideal for looking at activities done in the past.

3.6. Procedure for attribute valuation

Understanding how different households value different cow attributes may explain the adoption patterns of the dairy technologies in the study area. The binary choice model cannot determine the valuation of each of the attributes, instead it analyses a combination of the attributes embedded in the dairy cow. This may not bring out what attributes different households value or do not value. Attribute valuation has vital implications on the direction of developing dairy technologies.

3.6.1. Identification of Attributes

The analysis for the valuation of cow attributes started by identifying the relevant cow attributes followed by data collection that culminated into the second data set of the study.

Respondents were asked to indicate the reasons for adopting IDB. These reasons and their importance are shown in Table 3.4.

Table 3.4 Percentage of Households and their Main Considerations for Adopting IDBs

Reasons	Percentage of households with their main considerations for adopting IDBs (n=1000)
Tolerant to diseases	33
High milk yield	30
Better quality of milk	13
Increased traction	5
Tolerant to drought	7
Increased social status	0.3
Other reasons	11.7

Disease tolerance and milk yield were the attributes stated by most respondents as their

main considerations for adopting the IDBs. Therefore the two attributes were selected for CJ analysis. Animal diseases also ranked highest in the PRA that was done during characterization of the study area (Waithaka et al., 2002). Scarpa et al. (2003) also recognised animal diseases as a constraint, pointing out that yield stability is the underlying attribute for the high disease resistance trait preference, and farmers in the LDCs often take this as more valuable than yield *per se*. Disease tolerance and milk yield were therefore taken as the two most important attributes.

The first data set also highlighted the reasons different households gave for not upgrading the dairy herd (n=719): non-availability of cash or high cost of improved animals (35% of the households), high cost or difficulty in maintenance (13%), and not enough feeds/small holdings (6%). About 27% (n=215) stopped rearing IDBs because of their high feed requirements. According to Waithaka et al. (2002) the low number of cattle kept by each household is a result of low feed supply, particularly in the dry season. These facts delineate feed as a constraint in dairy production in the study area. Kariuki (1998) and Bebe (2003) state further that the main constraint to dairy production is inadequate feeds, especially during the dry season and generally the low nutritive value of available roughages. These facts justified the choice of feed requirement as the third attribute. Lack of funds to buy either the Dairy Cross or High Grade cows was among the stated constraints in the PRA (Waithaka et al., 2002), and this constraint has a direct influence on the price a farmer would agree to pay for a cow, hence the inclusion of price as one of the attributes. Price has always been a function of various attributes and characteristics, meaning that the marginal value of attributes and other characteristics

contribute to price. However market prices do not specifically provide signals on the marginal value of specific characteristics that are important to producers (Sy et al., 1994). Price is one of the attributes that define the overall quality of animals, and as one of the attributes it can be used to compute marginal utility for money and WTP (Gan and Luzar, 1993).

The attributes considered for analysis, therefore were disease resistance, feed requirement, milk yield, and the price of cows. The local Zebu has the highest resistance to diseases, while the crossbred has medium, and the purebred has low resistance. The levels for disease resistance were High, Medium and Low, and the respondents related to these levels in terms of the veterinary services required for the three categories of cattle. The Zebu requires minimal veterinary services while the High Grade needs the most.

The Zebu has a low feed requirement because farmers use mainly natural pastures and very little of planted fodder. The crossbred are in the medium level of feed requirement because they feed on natural pastures and a higher supplement of planted fodder and mineral supplements. The high-grade need the highest amount of planted fodder and concentrates. The levels were High, Medium and Low.

The Zebu grazes mainly on natural pastures, and produces an average of 1 litre of milk per cow per day. The crossbred dairy cow is mainly grazed with some stall-feeding, and produces an average of 5 litres per cow per day, while the High Grade can go up to 7 litres per cow per day (Waithaka et al., 2002). Data from the first data set showed that the

Pure- Grade can range from 9 to 24 litres of milk per cow per day. Therefore the levels adopted for the experimental design were;

a) 1 litre per cow per day-average from the Zebu,

b) 5 litres per cow per day-average from the Dairy cross, and

c) 15 litres per cow per day-average from the High Grade, a yield level that has not been realized by most of the farmers but is achievable in the study area.

The prices of cows were low during the long dry season and high during the long rainy season. The price of a Zebu cow ranged between Ksh 4,000 and Ksh 8,000. The price of the Dairy Cross ranged between Ksh 13,000 and Ksh 15,000, while that of the High Grade ranged between Ksh 25,000 to Ksh 30,000. Using these price ranges, the following price levels were chosen:

a) Ksh 4,000-the lowest price for the Zebu,

b) Ksh 15,000-the average price for the Dairy Cross,

c) Ksh 28,000-the average price for the High Grade.

The attribute levels and their combinations are devoid of the names of the breed in order to restrict the individual to the attributes in question. The abstract nature of the profiles removes the influence of the attributes not considered in the study.

3.6.2. Generation of the Orthogonal Design

With 4 attributes chosen, each at 3 levels, $81(3^4)$ full factorial combinations were obtained. The SPSS orthogonal design generator gives 27 combinations as the minimum possible orthogonal design. Blocking the 27 combinations resulted in nine different balanced incomplete block designs, each with three combinations. Adding two

combinations to each block, one with all attribute levels typical of a High Grade cow and the other with all attribute levels typical of a Zebu gave five profiles in each block. The two extreme profiles acted as the floor and ceiling of the profiles in each block, thus giving a good comparison with the other levels in between. The High Grade cow has high milk yield, high feed requirement, a high price, and low disease resistance, while the Zebu has low milk yield, low feed requirement, a low price and high disease resistance. Lazari and Anderson (1994) also included the extreme profiles in their CJ analysis of various food products, where two profiles were added to each block, one with all food products at low levels and the other at high levels. Table 3.5 gives the full orthogonal design and the blocks for the study.

Table 3.5 The Orthogonal Design used for Attribute Valuation

Milk yield Ksh per Litre	Feed requirement	Disease Resistance	Price Ksh per Cow	B1	B2	B3	B4	B5	B6	B7	B8	B9
5	Medium	Medium	28,000	1								
15	Low	Low	15,000	1								
1	High	High	4,000	1								
1	Low	High	4,000	1								
15	High	Low	28,000	1								
5	Low	Low	28,000		1							
1	Medium	Medium	4,000		1							
15	High	High	15,000		1							
1	Low	High	4,000		1							
15	High	Low	28,000		1							
5	High	High	28,000			1						
1	Low	Low	4,000			1						
15	Medium	Medium	15,000			1						
1	Low	High	4,000			1						
15	High	Low	28,000			1						
1	Medium	Low	15,000				1					
5	Low	High	4,000				1					
15	High	Medium	28,000				1					
1	Low	High	4,000				1					
15	High	Low	28,000				1					
5	Low	Medium	15,000					1				
1	Medium	High	28,000					1				
15	High	Low	4,000					1				
1	Low	High	4,000					1				
15	High	Low	28,000					1				
15	Medium	High	4,000									
1	Low	Medium	28,000						1			
5	High	Low	15,000						1			
1	Low	High	4,000						1			
15	High	Low	28,000						1			
1	High	Low	28,000							1		
5	Medium	High	15,000							1		
15	Low	Medium	4,000							1		
1	Low	High	4,000							1		
15	High	Low	28,000							1		
5	Medium	Low	4,000								1	
15	Low	High	28,000								1	
1	High	Medium	15,000								1	
1	Low	High	4,000								1	
15	High	Low	28,000								1	
1	Low	High	15,000									1
5	High	Medium	4,000									1
15	Medium	Low	28,000									1
1	Low	High	4,000									1
15	High	Low	28,000									1

Each respondent was asked to rank profiles in one of the 9 blocks.

3.6.3. Household Sampling and Questionnaire Presentation

The first data set consisted of data from seven districts, and it captured the various spatial factors related to dairy. Five districts comprising Rachuonyo, Kisii, Kakamega, Bungoma

and Nandi were chosen for this part of the study on the basis of their spatial, ethnic and cultural differences. Sixty percent of households from each of the four districts, including those without dairy cattle were selected through randomisation to obtain a sample of 630 households as shown in Table 3.6.

Table 3.6 The Households Surveyed by District

District	Households surveyed (from first survey)	60% of the households	Households with cattle	Households without cattle
Bungoma	162	96	50	46
Vihiga	334	201	140	61
Kisii	269	161	115	46
Nandi	123	74	62	12
Rachuonyo	158	94	64	30
Total	**1046**	**626**	**431**	**197**

According to Poate and Daplyn, (1993), the multi-stage sampling in this study satisfies the sampling rules. The rules demand that the geographical coverage, and the definitions of what factors to be included in the universe (sampling frame) must be clearly and explicitly defined. Furthermore it must be possible to observe the factors to be included in practice, hence the use of spatial factors for stratification.

To test the understanding of the questionnaire by both the enumerators and the respondents, the investigator, together with extension officers pre-tested the questionnaire. Twenty households were interviewed in Shisejeri and Shinyalu sub-locations of Kakamega District. The questionnaire was finalized taking into consideration feedback from all the extension officers involved in pre-testing.

Before commencement of the survey in each district, the investigator took one day to

train enumerators, consisting of extension officers from the respective districts. This was done in order to minimize ambiguity in understanding the questionnaire, and to address various logistical issues. One member from each household was interviewed, and to avoid enumerator fatigue, each enumerator filled four questionnaires per day at most, which were thoroughly checked by the investigator with the assistance of the district dairy officers. Each enumerator was paid for well-filled and accepted questionnaires. The first part of the questionnaire collected data on household and institutional characteristics, while the last part was on profile presentation and ranking (See Appendix II-B).

3.6.4. Profile presentation and ranking

According to literature, presentation of profiles can take the form of verbal description, pictorial presentation, card presentation or paragraph description. Baidu-Forson et al. (1997), Tano et al. (2003), and Sy et al. (1994) effectively used card presentations in their studies, and this method was adopted for the current study. The profiles were copied to each card, describing attribute characteristics, and individual respondents were asked to rank them.

Prior to ranking, the enumerators took time to explain to the respondents that the objective for ranking was purely for research purposes, and not for the purpose of giving cows as gifts, as earlier thought by most respondents during questionnaire pre-testing. The enumerators also ensured that respondents understood the ranking procedure. All the sampled respondents except one understood and ranked the profiles successfully.

3.7. Effect-Coding and the Ordered Probit Model

Data was entered into the computer by use of the Microsoft Access computer software, coded and analysed using the STATA statistical software. The rankings for each profile were recorded across all the observations and treated as dependent variables, while the effect-coded attribute levels and the household characteristics were independent variables. The effect-coding system by Tano et al. (2003); Adamowicz et al. (1994); and Sy et al. (1994) was adopted to enable direct interpretation of the probit model results. The effect-coding system is where the usual (0, 1) dummy system of the independent variables is replaced by a (-1, 1) system for two traits, and (-1, 0, 1) system for three traits. An attribute with only 2 levels will have only one attribute level included in the estimated model, while with a 3-level attribute, two levels are included and one level excluded. The parameters of the excluded levels are obtained by taking the sum of the parameters estimated and then taking the negative of the sum.

The attribute levels for the independent variables were discussed earlier in this section. Two attributes, disease resistance and feed requirement, had three effect-coded levels each, but the medium level of each attribute was omitted in the OPM models to avoid the dummy variable trap. Each attribute level had its column, and code 1 was for the level present in the ranked combination, 0 for the other levels absent in that combination, and -1 for the column of the omitted attribute level. The other attributes, milk yield and cow price retained their real values. For the categorical household characteristics, 1 was for the characteristic present in the household, while -1 for its absence in the household. Continuous variables were just recorded as they appeared. The continuous variable for

PPE was converted to discrete values, where 1 was for PPE greater than 1, while -1 was for PPE less than 1. This was necessary for easier interpretation of the results.

The first set of OPM was run, with technology attributes only, while the second had household characteristics included as independent variables.

The first OPM was:

$$Y^* = \beta_{HF} X_{HF} + \beta_{LF} X_{LF} + \beta_{HD} X_{HD} + \beta_{LD} X_{LD} + \beta_{price} X_{price} + \beta_{milkyield} X_{milkyield} + e$$

where Y^* were the rankings of the profiles, and they ranked from 1 to 5,

X_{HF} was high feed requirement attribute level, X_{LF} was low feed requirement attribute level, X_{HD} was high disease resistance attribute level, X_{LD} was low disease resistance attribute level. The β's were the marginal utilities arising from a change in the respective attribute levels, while e was the error term.

The second OPM was:

$$Y^* = \beta_{HF} X_{HF} + \beta_{LF} X_{LF} + \beta_{HD} X_{HD} + \beta_{LD} X_{LD} + \beta_{price} X_{price} + \beta_{milkyield} X_{milkyield} + \gamma X_g Z_h + e$$

Where $X_g Z_h$ was the interaction term between attribute levels (X_g) and household characteristics (Z_h). Letter g stands for HF, LF, HD, LD, price and milk yield, while h stands for all the household characteristics considered. Finally γ was the incremental marginal utility due to the household characteristics. The other terms were similar to the ones in the first OPM.

The negative of the ratio of the marginal utilities gave the MRS, and the marginal WTP was obtained if the denominator in the ratio of the MRS was the marginal utility arising from a change in the price of the cow. For example in the first OPM the MRS of low feed

requirement for high milk yield was:

$$\frac{-B_{LF}}{\beta_{milkyield}}$$

The ratio means that the household is trading off low feed requirement for milk that is equivalent to the result from the ratio. In the same OPM the marginal WTP for low feed requirement was:

$$\frac{-B_{LF}}{\beta_{price}}$$

In the second OPM the marginal WTP for an attribute was obtained when the marginal WTP from the interaction effect (X_gZ_h) was added to the marginal WTP due to a change in the attribute level. For instance the marginal WTP for low feed requirement was:

$$\frac{-\beta_{LF} + \gamma X_{LF} Z_h}{\beta_{price}}$$

Where h could be households with off-farm income.

The PC analysis was applied in the variables representing household characteristics, as shown in Table 1-C, Appendix 1. Variables with asterisk show that the variables were highly correlated, therefore, only one from each column was taken. From PC analysis the variables picked for analysis were education of the household head, income of the household, preference for cattle for traditional practices (trd), PPE, whether off-farm income was the main source of income or not (OfffarmYRank), education of the household head, and ethnicity of the household head (Nandi and Kisii).

Chapter IV

Results and Discussion

4.1. Description of the Study Area

The study area is home to four major ethnic groups, namely Luhya (50%), Kisii (32%), Luo (11%), and Nandi (6%), with other ethnic groups constituting only 1%. The Luhya are mainly located in Bungoma, Kakamega, and Vihiga Districts, while the Kisii are in Kisii and Nyamira Districts. The Luo are resident in Rachuonyo, while the Nandi are in Nandi District. There were 1498 agricultural and 77 non-agricultural households surveyed, making a total of 1575. However, out of the total sample, 1471 agricultural and 65 non-agricultural households provided the required data for analysis. Tables 4.1 and 4.2 show some of the key variables that were used in data analysis for adoption of dairy technologies.

Table 4.1 **A Description of all the Continuous Variables used during Data Analysis**

Variable	Variable description	Mean	SD	Minimum	Maximum	n
Hhage	Age of the household head in years	48.36	14.05	15	92	1471
Hhexperience	Experience of the household head in years	20.46	14.03	0	66	1471
PPE	Precipitation over Evapo-transpiration index. It combines average effects of rainfall, altitude and sun radiation	1.06	0.16	0.73	1.34	1471
Popn	Population density in terms of persons per $100km^2$. A proxy for milk market access	625	347	124	1648	1471
Popdensity	Population density in terms of persons per $5km^2$. A measure of land pressure and fodder availability	4.89	10.15	0.09	240	1450
TNUrdtype2km	Distance to the nearest urban centre on murram road	6.91	6.73	0	29.18	1460
TNUrdtype1km	Distance to the nearest urban centre on tarmac road	16.91	9.75	0	44.72	1460
TNUrdtype3km	Distance to the nearest urban centre on earth road	2.41	2.83	0	12.46	1460
hhmemb	Number of household members	5.96	2.62	1	20	1471
presentlandsize	Current land size in acres	3.22	4.58	0	70	1471
education	Number of years of education of the household head	7.63	4.50	0	19	1471
dependency	The ratio of pre-school and school-going household members to adults in the household	1.6	1.12	0	8	1324

Table 4.2 A Description of all the Categorical Variables used during Data Analysis

Variable	Variable description	0%	1%	n
transport	Do you have transport on the farm? 1=Yes, 0=No	50	50	1471
Dairy10	Did you have improved dairy cows 10 years ago? 1=Yes, 0=No	73	27	1471
Fodder10ago	Did you have planted fodder 10 years ago? 1=Yes, 0=No	76	24	1471
ownermanager	Farm owner as well as manager. 1= farm owner and manager, 0=Otherwise	42	58	1461
Exttopicsolstck	Extension on livestock. 1= Extension on dairy, 0=Otherwise.	66	34	1011
Luhya	1=household head is a Luhya, 0=Otherwise	51	49	1471
Luo	1=household head is a Luo, 0=Otherwise	89	11	1471
nandi	1=household head is a Nandi, 0=Otherwise	93	7	1471
kisii	1=household head is a Kisii, 0=Otherwise	68	32	1471
Anylabour	1= Hired Labour on the farm, 0=Otherwise	44	86	1471
fooddrank	1=Rank of food as the main expenditure, 0=Otherwise	42	58	1471
offfarmYrank	1=Off-farm income as the main source of income, 0=Otherwise	50	50	1471
Inc	The income category of the household. 0=Upto Ksh5,000 per month, 1=5,000 ->30,000	72	28	1471
SellMilk	Do you sell milk? 1=Yes, 0=No	85	15	1471
gender	1=Male household head, 0=Female	18	83	1471

From Tables 4.1 and 4.2, only the variables for agricultural households are discussed hereafter.

Access to markets and services determine adoption of technologies, where a higher access may influence adoption of dairy technologies. The average distance (in km) from the agricultural households to urban areas and other characteristics are shown in Table 4.3.

Table 4.3 **Average Distance (in km) from the Households to the Nearest Urban Center by Road type together with Land size, and Population Density by district**

	Whole sample n=1471	Bungoma n=139	Kakamega n=267	Kisii n=256	Nandi n=119	Nyamira n=229	Rachuonyo n=157	Vihiga n=304
Type of road								
Tarmac	16.9(9.8)	9.4(5.1)	15.7(2.6)	22.8(11.4)	28.6(6.7)	23.07(9.4)	7.5(7.86)	11.92(3.1)
Murram	6.9(6.7)	7.9(3.9)	5.8(4.3)	5.4(5.2)	9.4(7.9)	6.4(6.5)	15.9(8.7)	3.47(4.4)
Earth	2.4(2.9)	0.73(0.9)	2.1(1.8)	1.91(2.4)	4.96(3.3)	4.02(3.9)	2.43(2.6)	1.61(2.1)
Land Size	3.2(4.6)	3.8(5.1)	2.4(2.8)	2.7(2.9)	6.9(9.9)	2.9(2.9)	4.7(5.5)	2.1(2.3)
Land Size when farm was established	3.3(5.8)	6.6(13.4)	2.7(4.4)	2.6(2.4)	5.8(7.6)	3.1(3.6)	4.5(4.8)	1.7(1.8)
Population density	4.9(10.1)	4.9(8.2)	5.2(7.5)	4.3(4.3)	2.5(2..7)	6.1(19.3)	2.1(1.8)	6.7(10.5)

Please note: **Figures in brackets are standard deviations**

Urban areas, defined as centres with populations of at least 50,000 people, are markets for farm produce, labour, and sources of goods and services for households. Households in Nandi had the longest distance to urban areas by tarmac, while those in Rachuonyo had the longest distance from the household by murram road.

Statistics on land sizes showed Nandi with the highest mean acreage of 6.9 acres, while Vihiga had the smallest (2.1, F=24.24**). Households in Bungoma had a significant land reduction from a mean of 6.6 to 3.8 from the time the farms were established (t=2.25**). The other districts had no significant changes in land sizes. This shows that there was land pressure in all the districts because of the positive population growth rate. Vihiga had the highest population density, followed by Nyamira, while Rachuonyo had the lowest density.

About 83% of the household heads were male (n=1471). However 47% of the households had female farm managers, meaning that many female members manage farms but were

not the household heads. Gender is a major factor in relation to resource endowment, and Table 4.4 shows that male headed households were more endowed in resources than the female headed households.

Table 4.4 The Households Heads according to Gender and their Resource Endowment

N=1471	Male household heads	Female household heads	Significance
Characteristic			**t-ratio**
Age	50(14)	48(14)	2.27**
Years of education	8.3(4.3)	4.7(4.3)	12.27**
			Chi-Square
Ownership of Transport	52%	38%	16.51**
Income below Ksh 5,000	68%	80%	15.44**
Access to Labour	58%	49%	5.64*

Source: Author's Analysis

From Table 4.4, male household heads were older, had more education, a higher access to income, transport and labour. The households heads had a mean of 7.6(4.5) years of education. About 14% of the household heads had no education, 53% had up to 8 years, 24% had between 10 and 12 years, while 8% had between 14 and 19 years of education. Kakamega, Nandi and Rachuonyo had below average levels of education. On average there were six household members in every district.

Transport is essential in moving farm inputs to, and harvested produce from the farm. Nearly 50% of the households owned some form of transport. The bicycle was the main source of transport, where 62% of the households used it, followed by the wheelbarrow with 33% of the households. Sixty eight percent of the households employed labour, with

54% employing casual labour, mostly for crop production, while 14% had permanent labour.

Regarding credit, 68% of the households responded to the question of its availability, of which 96% said they did not get credit. Generally, lack of knowledge on credit was the most common reason for not accessing credit, and Rachuonyo had the highest percentage (64%) of households that said they did not know any source of credit. The fear of inability to pay, which may indicate risk aversion, was greatest in Bungoma and Nandi, with 34 % and 33% of the respondents, respectively, citing it as the reason for not accessing credit.

Ranking different household income sources showed the importance of the income sources to the households. About 46% of the households (n=1471) ranked farm income, while 38% ranked wage income as their main source of income. Eleven percent ranked remittances, while only 1% ranked rent as their main source of household income. Kakamega had the highest percentage of households with wage income (65%), while Nandi had the lowest (19%). Table 4.5 shows how different households ranked different sources of income.

Table 4.5 Households' Ranking of different Sources of Farm Income

Farm income sources	Percentage of households with their main farm activities							
	Whole sample n=1224	Bungoma n=124	Kakamega n=194	Kisii n=199	Nandi n=111	Nyamira n=198	Rachuonyo n=115	Vihiga n=254
Dairy	20	14	16	17	29	14	16	31
Cash crops	26	10	8	35	19	59	24	20
Food crops	44	65	58	41	47	16	59	38
Horticulture	6	9	8	2	4	9	0	6
Fuel wood	2	1	4	1	0	2	1	3
Other farm activities	2	1	6	4	1	0	0	2

The highest percentage of households (44%) stated food crops as the main source of farm income, followed by 26% who stated cash crops, and only 20% stated income from dairy as their main source of income. Dairy farming therefore was ranked third as a source of farm income. Bungoma, Kakamega, and Rachuonyo had sugarcane as the main cash crop, and had more households that ranked food crops as the main source of income. Maize, beans, bananas, and sorghum were the main food crops. More households in Nyamira had cash crops (tea) as the main source of income. Nandi and Vihiga showed diversity of farm income sources, with a wider distribution of households in each category of the first three income sources. Kisii, Nyamira, and Vihiga had maize-beans intercrop, millet, bananas, and sorghum as the main food crops, while coffee and tea were the main cash crops.

Income distribution was sharply skewed, with 72% of all the households having Ksh 5,000 per month or below. Only 4% of the households earned at least Ksh 20,000. About 58% of the households ranked food as the highest expenditure, followed by school fees (33 %), leaving little for savings and investment. Eighty four percent of the respondents in Kakamega District (n=267) said they allocate the highest proportion of their income to

food. Fifty one percent of the respondents (n=229) in Nyamira District allocate the highest proportion of their income to school fees. According to Engel's Law, households that allocate a larger share of their income to food are considered poor (Ritson, 1977). Most households in the study area may therefore be considered poor as they allocated a larger proportion of their income to food. In addition, according to the FAO/WHO requirements the Absolute Poverty line is Ksh 1239 per adult-equivalent per month (Kenya Government, 2000). The average household size in the study area was 6 members. But this included children, so it can be scaled down to a size of 4 adult-equivalent, thus making the poverty line to be Ksh 4945.6 per household per month. Therefore the 72% of the households with a farm income of Ksh 5000 per household per month and below were considered poor.

Division of labour was evident in the study area. Males in the household grazed cattle and looked for AI services, while the females cleaned, fed, planted forage, milked and marketed the milk, and watered the animals. Between 8% and 11% of the households across the districts used labourers for cattle-rearing, while up to 7% of the households had children performing different roles. The adult family members therefore provided labour, while children were more of dependants than labour suppliers. The use of hired labour was quite minimal. There were very few households with telephone services, electricity and piped water.

Intensification can be defined in two dimensions (Staal et al., 2001). First it is land cultivation that results in higher biomass production and feed availability per animal from

land resources within the production unit. Second, it is a measure of feed levels imported into the production unit. Crop-livestock interaction therefore lands in the first dimension. In the survey area crop-livestock interaction involved feeding Napier, natural pasture, and other crop residue to cattle, and taking manure to the farm. Other indicators of intensification could be the level of milk production, system of keeping cattle and the kind of breed, proportion of cropped land to total farm size, proportion of cost of purchased feed to total feeding cost, and proportion of cash income from sale of animals to total dairy income.

Households in the study area mainly use the crop-livestock strategy for intensification, but its level is quite low. Over 70% of the households strive to increase soil fertility through soil conservation measures, use of manure and inorganic fertilizers. However the manure and fertilizers applied are below the recommended rates. In addition only a few types of the wide range of fodder were utilized. Fertilizer was not used in fodder production yet studies have shown that fertilizer use in Napier increases its quality (Kariuki, 1998). Some households without cattle grew Napier for sale, but did not use manure, a situation that renders the crop-livestock interaction cycle incomplete. This creates a negative nutrient balance. In addition fuel wood, the most prevalent type of fuel, was collected from farms, an activity that depletes nutrients from the farm. This is where market or exchange mechanisms should transfer manure and crop residues between the independent production units, an activity that Staal et al. (2001) refers to as area-wide crop-livestock integration. This means that manure and crop residues can be bought from one farm to another, and cash from the sale can be used to purchase fertilizer.

4.2. Adoption of Improved Dairy Technologies

Sixty nine percent of all the agricultural households had cattle, of which 40% had IDBs. Households in Nandi District had reared the IDBs for 16 years, while those in Kakamega District had reared them for nine years. Acquisition of IDBs was mainly by purchasing from neighbours. The different breeds in the area were; Local Zebu 47%, Holstein Friesian (cross) 19%, Ayrshire (cross), 18%, Holstein Friesian (pure), 3%, and Guernsey (cross) 9%. About 27% (n=1471) of the households kept dairy10 years ago. Only 22% of those who had dairy 10 years ago had stopped keeping them. Sixty three percent (n=994) of the households indicated that tolerance to diseases and high milk yield were the two main reasons for keeping their favourite breeds. Tolerance to diseases was ranked highest in Rachuonyo, Kakamega, and Bungoma, while most households in Nandi, Kisii, Nyamira and Vihiga ranked high milk yield highest. Table 4.6 compares the characteristics and endowment of households with and without IDBs.

Table 4.6 Characteristics of Households with and without IDBs

Characteristics	No IDB		IDB		
	Mean	SD	Mean	SD	T
Age of household head	47	14	50	13	4.17***
Farming experience of household head	19	14	23	14	6.02***
Population density	5.7	12.44	3.7	4.82	4.31***
PPE	1.03	0.16	1.11	0.14	10.21***
Education of household head	7	4	8	5	3.05***
	Number of households	% of households	Number of households	% households	chi-square
Extension visits					
No	744	84	350	60	104***
Yes	144	16	233	40	
Transport					
No	505	59	230	39	43*
Yes	383	43	353	61	
Income category					
Upto Ksh5,000/month	705	79	347	60	68**
Over Ksh5,000/month	183	21	236	40	

Source: Author's Analysis

*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level**

Household heads with IDBs were older, had more farming experience, a higher level of education, and were located in higher PPE areas. In addition households with IDBs were associated more with higher income, access to transport and extension visits than those without. Because dairy farming was not the main source of income, most of the income could be from other farm activities and off-farm income other than dairy. This suggests that dairy was being adopted by households that already had resources from other farm activities.

About 26% of all the households with cattle (n=1015) received extension services. Bungoma and Kakamega received the least extension services. The extension services provided for by the Government of Kenya still dominated. Other extension services were from NGOs, co-orperatives, and individuals offering private services. Services for AI were received by less than 4% of the households. Almost all households (94%, n=1015) graze their cattle. This indicates low pressure on land compared to areas like Kiambu, where only 28% of the households graze their animals (Staal et al., 1997) and Meru where there was no land for grazing (Batz, 2000). The highest percentage of households with IDBs came from Nandi (82%, n=119). Vihiga, Nyamira and Kisii exhibited diversity in the use of forages while Nandi and Rachuonyo had less than 10% of the households using fodder. Other types of fodder were roadside grass, forage legumes and crop residues. About 84% of the households with cattle said they experienced feed shortage at certain periods of the year. Maize stover was the most common fodder, followed by Napier, and banana stems. According to Kariuki (1998) Napier has qualities that make it superior to other forages. About 62% of the households had Napier, but 11% had Napier but no cattle, meaning that some households grew Napier for sale. Rachuonyo, Kakamega, Nandi, and Bungoma had less than one acre of Napier per household, while the rest of the districts had more than one acre. Table 4.7 compares the characteristics and endowment of households with and without Napier.

Table 4.7 Characteristics of Households and Use of Napier

Characteristics	No Napier		Napier		
	Mean	SD	Mean	SD	t
Age of household head	48	15	49	13	1.53(ns)
Experience of household head	17.9	14	22	14	5.4***
Population density	5.2	10.7	4.7	9.8	0.87(ns)
Education of household head	7.5	4.6	7.7	4.4	0.97(ns)
PPE	0.98	0.15	1.12	0.14	17.4***
	Number of households	**%**	**Number of households**	**%**	**chi-square**
IDB					
No	477	84	411	45	219.6***
Yes	89	16	494	55	
Extension Visits					
No	482	85	612	68	56.17***
Yes	84	15	293	32	
Transport					
No	304	54	431	48	5.15*
Yes	262	46	474	52	
Gender					
Female	101	18	156	17	0.09(ns)
Male	465	82	749	83	

Source: Author's Analysis

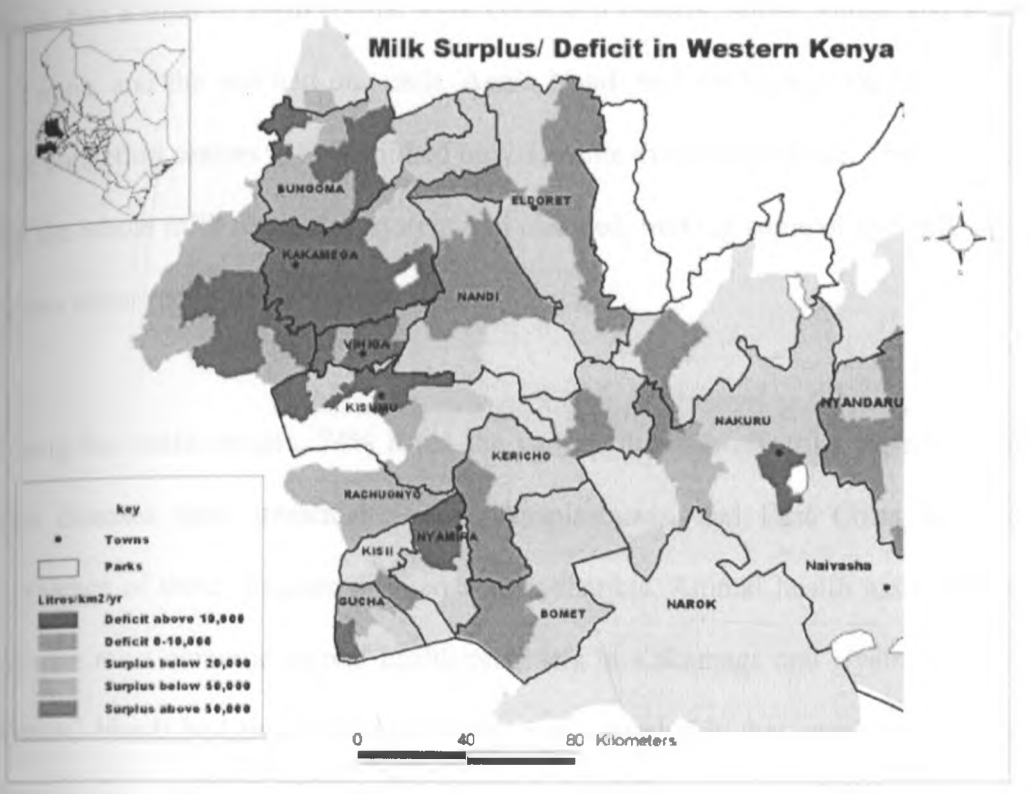
*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level**

The 't' ratios indicated no significant difference in age, population density and education between the households with and without Napier. However household heads with Napier

had a higher farming experience and were located in areas with a higher PPE than those without. The chi-square shows that households with Napier were associated more with rearing IDBs, access to transport and extension services than those without.

Whenever they have lactating cows, households milked two times a day. There was a variation in milk production per household per day across the districts, with Nandi having the highest (5.2 litres), double the amount produced in Rachuonyo, the lowest producer. At the time of the survey only 22% of the households with cattle (n=1015) were selling milk, with some variations among the districts. This is an indication that some households either did not produce milk or did not have surplus for sale. This depicted localized surplus and deficit areas as shown in Figure 4.1.

Figure 4.1 Surplus and Deficit areas in Western Kenya



Source: Author's Analysis by use of the GIS

Prices are also indicative of surplus and deficit areas because in reasonably competitive markets, prices measure the scarcity of a commodity, where deficit areas face high prices and vice-versa. Kakamega registered an average of Ksh 25 per litre, Vihiga Ksh 24.20, Bungoma Ksh 23, Kisii and Rachuonyo Ksh 21, Nyamira Ksh 20, and Nandi Ksh 16. Most households sold milk in the neighbourhood, and about 90% of the households had no selling difficulties whenever they had milk for sale. Population density therefore qualified as a proxy for access to milk markets, while distance was a proxy for access to inputs. Delayed payment was the main problem in milk-marketing, and this could be because most households had very low incomes and therefore were not able to pay in

time. The formal milk collection centres in the area did not serve many households. Nandi had a total of eight formal milk collection centers, while Vihiga and Kakamega had none, and the rest had one each. Again Nandi had the highest number of informal milk collection centres (31), Kisii had only 3, while the rest had none. This was a pointer that the whole milk marketing system had changed, making some of the milk collection centres either redundant or to work below capacity.

Among the cattle owners, 74% listed the various diseases affecting their herd, and the main diseases were Intestinal worms, Anaplasmosis, and East Coast Fever (ECF). Prevalence of these diseases differed across districts. Animal health assistants (AHAs) were the most common animal health providers in Kakamega and Nyamira. Across the districts, Nandi had the highest percentage of households that received services from veterinarians (17%), while Rachuonyo had the highest proportion that was serviced by herbalists (30%). Kisii had the highest percentage of households that administered self-treatment (23%), while Nandi was highest in those that did not give any treatment (24%).

Anti-helminthics were used as a preventive measure by 62% of the households with cattle (n=1015). Table 4.8 shows the characteristics and endowment of households with and without anti-helminthics use.

Table 4.8 Characteristics of Households and Use of Anti-helminthics

Characteristics	No Anti-helminthics		Use of Anti-helminthics		
	Mean	SD	Mean	SD	t
Age of household head	52	14.1	50	13	2.15*
Farm experience	24	14.6	22	13	1.89*
Education	7	4.3	8	5	-5.56***
	Number of households	% of households	Number of households	% of households	chi-square
IDB					
No	232	60	205	32	76***
Yes	152	40	426	68	
Extension visits					
No	284	74	354	56	32.6***
Yes	100	26	277	44	

Source: Author's Analysis

*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level**

Households that used anti-helminthics had younger household heads with a lower farming experience and a higher level of education. Households with IDBs and those who accessed extension services were associated more with anti-helminthics use than those households without. A summary of the adoption rates of dairy technologies is shown in Table 4.9.

Table 4.9 **Rates of Adoption for Different Dairy Technological Components**

Technology	% of households	Observations
Improved dairy cow	40	1471
Plant Napier	61	1471
Use of Anti-helminthics	62	1015
Use of Acaricides	90	1015
Bucket Feeding of Calves	21	466 (all households with calves)
Feeding of Minerals	15	1015
Manure Pit	3	1015
Use of concentrates and commercial feeds	16	1015
Livestock written records	10	1015

The IDB forms the primary dairy technology, while the secondary components can be divided into three categories: feeding, health, and management. It was difficult to do an exhaustive study of all the components, therefore only a few basic technologies were chosen for further study. The components with a big sample size and a considerable rate of adoption were Napier production, use of anti-helminthics, and acaricides. Napier production represented the feeding technologies, while the use of anti-helminthics was chosen to represent the animal health technologies. In addition almost all the households used acaricides, meaning that there was little variation in the sample regarding its use. On the other hand, bucket-feeding of calves, feeding of minerals, concentrates and commercial feed, record keeping, and manure pit construction had low adoption rates (below 25%), making the analysis of such technologies to have little meaning. The use of concentrates is a production risk, and the farmer may avert this risk in situations where fodder is readily available (Staal et al., 2000). Adoption of the IDBs, Napier production,

and use of anti-helminthics, were the components taken up for study. Figure 4.2 shows adoption rates of the three components by district.

Figure 4.2 Adoption rates of IDB, Napier, and Anti-helminthics by district

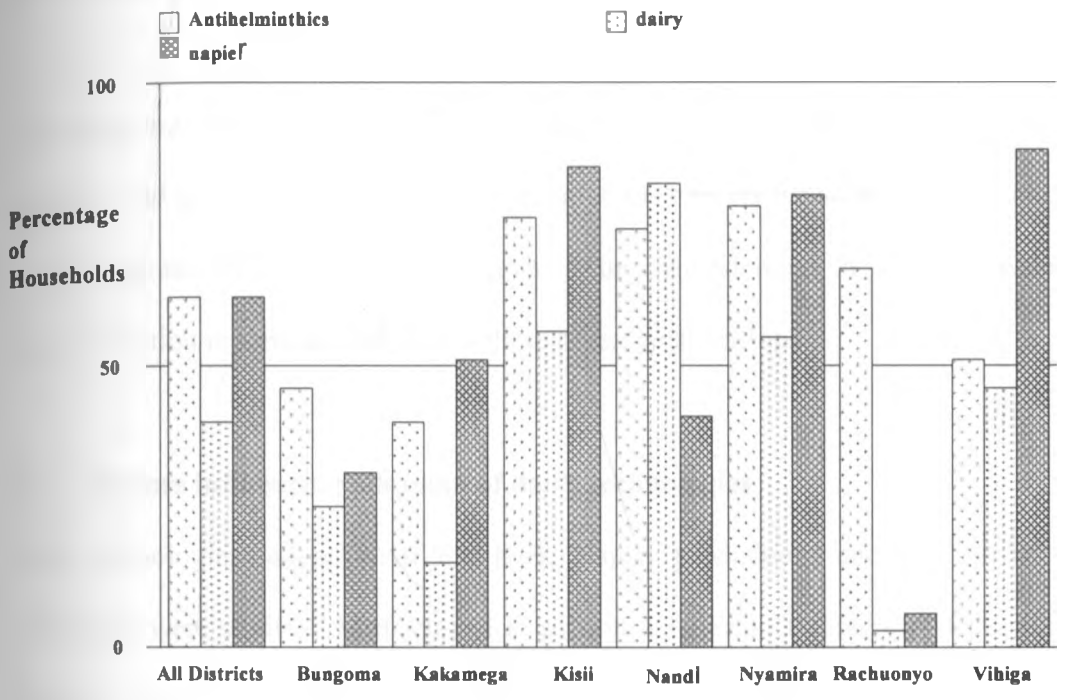


Figure 4.2 shows that the IDBs had the lowest adoption rate. The adoption rates of Napier and anti-helminthics mean that some households planted Napier but had no dairy, and anti-helminthics were also given to the Zebu. The use of anti-helminthics was highest in Kisii and Nyamira districts and lowest in Kakamega and Bungoma districts. Nandi, Kisii and Nyamira districts had the highest adoption rates of IDBs, while Rachuonyo and Kakamega districts had the lowest. Napier production was highest in Vihiga, Kisii and Nyamira districts and lowest in Rachuonyo, and Bungoma districts. Rachuonyo had adoption of anti-helminthics much higher than that of IDBs and Napier.

Taking the three technologies together, the districts depicted varied adoption rates with Kisii, Nyamira and Nandi having the highest rates, while Rachuonyo the lowest rates. The differences in adoption meant that some households experienced constraints to adoption thus justifying the analysis of the different factors that influence adoption.

The foregoing descriptive analysis, although important in identifying the relevant variables, and giving complementary information on reasons for adoption, does not give causal relationships among various factors influencing adoption of dairy technologies. The next section reports an analysis on these causal relationships.

4.4. Factors influencing adoption of dairy technologies

Three technologies: adoption of the IDB; Napier production; and the use of anti-helminthics were studied. As discussed in section 4.3. From the review of the existing literature, various factors have been hypothesised to influence adoption of IDBs, Napier production and use of anti-helminthics as shown in Table 4.10.

Table 4.10 The Variables Influencing Adoption of Dairy Technologies

Variable name	Description of independent variable and the hypotheses
Inc	+ rearing a dairy cow and adopting the associated technologies is capital intensive, therefore needs more resources
gender	+/- a proxy for access to resources, and male household heads had more resources. women had the responsibility of taking care of young members of the family hence keep dairy to increase income and nutritional standards.
gender*education	-educated male household heads will look for off-farm employment and not engage in farming activities
Exttopicsonlstock	+households that had extension services on livestock are more likely to adopt than those who did not
Exttopicsonlstock *education	+education influences adoption in households that had no extension services
presentlansize	+/- More land means more natural pasture and crop residue on the farm therefore it increased the probability of adopting the improved dairy cow but reduces the probability of planting Napier
Dairy10	+ households that had dairy 10 years ago had more experience in rearing IDB
Fodder10ago	+ households that had dairy 10 years ago had more experience in growing fodder than those who did not
TNUrdtype3km	-the longer the distance from the household to the nearest urban centre, the lower the access to extension and health services necessary for adoption of dairy technologies. This captures the transaction costs when seeking services in the nearest urban area
ownermanager	+A household head who manages his own farm will increase intensification
education	+ household heads with a high level of education are less risk averse and had a higher allocative ability, therefore will take up dairy technologies
hhage	-older household heads are more risk averse therefore will not adopt dairy technologies
Kisii	+the Kisiis are more enterprising than the Luhyas, therefore will adopt technologies that are market oriented
Popn	+ a high population increased access to milk markets because most households with a milk surplus sell to their neighbours
PPE	+ a high PPE favours fodder production thus reducing production costs
dependency	+/- a high dependency may drain the household's resources required for investment. It may also give incentives to increase milk production
offfarmYrank	+ household heads with off farm income as the main source of income invest in dairy technologies
fooddrank	- households that spent most of their income on food are considered poor and therefore did not have capital to invest in dairy

+ means the variable will increase the probability of adoption while the
- means the variable will reduce the probability.
*** means interaction**

Income is a proxy for availability of capital. Dairy technologies are capital intensive, and households with more income have the ability to adopt technologies. The extension variable stands for whether households received extension service on livestock or not, and was treated as exogenous because extension service, especially from the Government of Kenya is not normally targeted to those households with IDB alone. It was hypothesized that households that had cattle 10 years back had more experience than those that did not have cattle at that time. A household can easily buy or dispose off IDBs

within a period of 10 years, therefore the variable that represented whether or not the household had IDBs 10 years back, was not endogenous in the model. The same explanation applied to households that had fodder 10 years back. The variable that represented household heads managing their own farms, was a proxy for the incentive to practise intensification, and was exogenous. The ratio of school-going or pre-school children to the adults in the households measured the level of dependants in the household. School-going or pre-school children draw a lot on the household resources in the form of school-fees, food, clothing, and time. This category of household members had minimal contribution to the household's labour supply (only 7% of the households used labour from children). The three GIS-derived spatial variables, population density, PPE, and distance to the main road by earth road, were considered exogenous. The other variables: gender of the household head, years of education of the household head, and land size in acres, were obvious cases of exogeneity.

The introduction of interaction variables means that the effect of one independent variable on the dependent variable is hypothesized to vary by levels of another independent variable. The variable showing interaction between gender and education had the hypothesis that male household heads with a high level of education went for off-farm employment rather than engage in farming activities. The variable showing interaction between education and extension hypothesises that educated households increase the ability to make better use of information, therefore increased the probability of adoption.

The three models estimated were:

(i) Adoption of Improved Dairy Breed (IDBs) = f (independent variables)

(ii) Napier Production= f (independent variables)

(iii) Use of Antihelminthics = f (independent variables),

where the variables on the left hand side were the dependent variables. The probit model, a dichotomous choice model with 0 and 1 as values of the dependent variable was used to estimate factors influencing adoption. A dependent variable takes the value of 1 if adoption occurred, 0 otherwise.

A test of endogenoity between each of the variables: Adoption of Improved Dairy Breeds (IDBs); Napier Production; Use of Antihelminthics, and Income showed non-significance of the correlation factor (rho) in the results shown in Tables 1-D, 1-E, and 1-F, Appendix 1, meaning that there was no correlation in the error term, therefore no interdependence between income and any of the dairy technologies. Household income can therefore be included in each of the three equations: adoption of the IDB, Napier production, and use of anti-helminthics, as an exogenous variable without violating recursivity. This means that the dairy technologies had not reached a stage where substantial income is generated from them, and this is justified from earlier findings in section 4.1 that income from dairy farming came only third in the rank of different types of farm income. Table 4.11 shows probit estimates with income as the dependent variable, which took a value of 1 if the level of household income was above Ksh 5,000, and 0 if below Ksh 5,000.

Table 4.11 The Estimated Probit Model for Income (Inc)

Income	Robust coefficients	Standard Error
offfarmYrank (Do you have off farm income?) 1=Yes, 0=No	0.46***	0.09
fooddrank (The main expenditure in the household) 1=Food, 0=Otherwise	-0.42***	0.09
education (education of the household head in number of years)	0.11***	0.01
presentlandsize (Total land size for the household in acres)	0.05***	0.01
dependency (Ratio of dependants to adults in the household)	-0.03	0.04
Kisii (Ethnic background) 1=Kisii, 0=Luhya	-0.23**	0.09
hhage (age of the household head in years)	0.01***	0.003
gender (gender of the household) 1=Male, 0=Female	0.01	0.12
Constant	-2.09***	0.26
No. of observations	1315	
Wald (chi-square)	197	
Prob > chi2	0.0000	
Percent of correct prediction:		
High income	73	
Low income	78	
Overall	77	

Source: Author's Estimation

Note: values in brackets are standard errors
*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level**

Table 4.11 shows that three variables, namely availability of off-farm income in the household, education of the household head, and land size contributed positively to household income. Off-farm income was also likely to increase household resources, which shows that on-farm income was still inferior, and that the agricultural sector, where the majority of the labour force is, still had lower incomes compared to other sectors. These findings are in concurrence with the enormous body of literature that links

agriculture in LDCs to low incomes. This also reflects the low opportunity cost of labour in the rural areas. For instance, Timmer et al. (1983) showed that incomes in African urban areas, a common source of off-farm employment, are at least 10 times more than those in the rural areas. These differentials, the study states, are in part, a symptom of distorted macro-policies, which depress rural growth and cause rural-urban migration. The fact that educated household heads increased household income implies that a higher level of education had a higher allocative ability (Lapar and Pandey, 1999; Feder et al., 1985) thus increasing productivity with a consequence of higher farm income. Table 4.11 also shows that older households had higher income. Households that ranked food as the main expenditure had lower incomes, quite in line with the Engel's Law, which states that households that spend most of their income on food are resource poor (Ritson, 1977). The dependency ratio and gender *per se* did not have a significant effect on the income of the household.

The non-significance of the correlation factor (rho) in Tables 1-G, 1-H, and 1-I, Appendix 1, after pair-wise estimation of the three models also depicts a lack of contemporaneous correlation of the error terms. This means there was a low complementarity in the use of the three technologies under study. Therefore estimates of the single equation models were still efficient. For high intensification, complementarity of all the improved dairy technologies is a strategy strongly advised by the market-oriented smallholder dairy (MOSD) project. Low complementarity shows that there are low feeding management and poor health services resulting in low animal productivity. Table 4.12 shows estimates from single equation probit models,

where the three dairy technologies were the dependent variables while other factors were the independent variables.

Table 4.12 The Estimated Probit Models of IDB, Napier, and Anti-helminthics

	Marginal effects of the independent variable		
Independent variable	**impdairy**	**napier**	**anti-helminthics**
inc (Monthly Income category of the household) 1=above ksh 5,000, 0=below ksh 5,000	0.12 (0.11) ***	0.09 (0.13) ***	0.15 (0.11) ***
gender (gender of the household head) 1=male, 0=Female	ns	0.200(0.23) ***	ns
Presentlandsize (land size in acres)	-0.01(0.01) ***	-0.01(0.01) ***	ns
Fodder10ago (Did you grow fodder 10 years ago?) 1=Yes, 0=No		0.08 (0.14)***	
Dairy10 (Did you have dairy breeds 10 years ago?) 1=Yes, 0=No	0.43(0.12) ***		0.17 (0.11) ***
TNUrdtype3km (The distance by earth road from the household to the nearest urban centre by earth road)	ns	-0.01(0.02)*	ns
exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise	0.16 (0.19) **	ns	0.21(0.19) ***
exttopicsolstck*education	ns	0.1(0.02) ***	ns
Ownermanager (Owner of the farm as well as manager?) 1=Yes, 0=Otherwise	ns	ns	ns
Education (education level of the household head)	ns	0.01(0.03)*	ns
gender*education	ns	-0.01(0.03)*	ns
Kisii (ethnic group of the household head) 1=Kisii, 0=Luhya	0.16 (0.12) ***	0.21 (0.17) ***	ns
Popn (Population density in persons per km^2at 5 km radius)	ns	0.0002(0.0002) ***	-0.0001 (0.1) **
PPE	0.54(0.34) ***	0.90(0.55) ***	ns
dependency (ratio of pre-school and school-going household members to adults in the household)	-0.03(0.04) **	ns	ns
OfffarmYrank (Off-farm income status of the household head) 1=Off-farm income as main source of income, 0=Otherwise	-0.08(0.10)**	ns	ns
fooddrank (1=Rank of food as the main expenditure) 0=Otherwise)	ns	ns	-0.33 (0.09) ***

Hhage (age of the household head in years)	ns	ns	ns
Constant	-1.63 (0.46)***	-4.12 (0.62) ***	n
observations	921	927	921
Wald chi-square (14)	217	215	163
Prob > chi2	0.0000	0.0000	0.0000
Percent of correct prediction:			
Adopters	79.33	87.93	74.69
Non-adopters	69.49	77.03	65.20
Overall	74.92	85.67	71.88

Source: Author's Analysis

Note: values in brackets are standard errors
*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level**

The base change[3] for PPE is 10 (100 x 0.1), while that of population density is 100 (1x100). The other continuous variables have a unit base of 1. The marginal effects represent percentage changes in the probability of adoption associated with a change in the independent variable. In order to correct for heteroscedasticity, a common problem in cross-sectional data, the Huber-White method (Gujarati, 1995) was used to generate robust standard errors. The Wald statistic is significant at all levels of significance, implying that the association of the independent parameters with adoption of dairy technologies is significantly different from 0. The predictive accuracy for the models was at least 70% for adopters, and they were predicted more accurately than non-adopters in each of the models. The prediction value was obtained by calculating the proportion of predicted adopters that were actually adopters. The prediction value for non-adopters was obtained in the same way, and Table 1-J, Appendix 1 shows the classification for the predicted adopters and non-adopters.

Table 4.12 shows that an income of more than Ksh 5,000 was associated with at least a 9% increase in the probability of adopting each of the three technologies. This confirmed the widely held view that dairy is money capital intensive. High capital intensity was depicted in the fact that the cost of one IDB in the study area ranged from Ksh 15,000 to 28,000, a significant amount for the households in the study area because most of them

[3] The base change of 10 for PPE arose from the fact that one unit change in the variable measures a very wide variation in PPE, therefore the unit change was reduced to 0.1. The base change for household density to 100 means that instead of measuring the response from a change of 1 person per km2, the response was measured from a change of 100 person per km2

earned less than Ksh 5,000 per month. In addition, the IDBs need labour and transport to cut and carry fodder, veterinary and AI services for high level of management, and all these activities require money capital.

Households with non-farm income as the main source of income were wealthier than those that did not have non-farm income as the main source of income (Table 4.11). Non-farm income, mostly wages, was received by 50% of the households, who ranked it as the main source of income. However the results in Table 4.12 show that these households did not invest in dairy, a finding that depicts a lack of interdependence between dairy and the non-farm sector. Apart from credit that was received in kind from tea and sugarcane production, households did not receive credit for other farming activities, dairy included. Dairy co-operatives, another possible source of credit, were non-existent in most parts of the study area. Table 4.12 shows that households with non-farm income did not use it on dairy development. It was therefore unlikely that most households were constrained by lack of credit in adoption. Capital was therefore a necessary but not a sufficient condition for intensification. Credit will only be a constraint when households have used up all the liquidity available and need additional capital to invest. Unless there is derived demand for credit, additional liquidity may go to other investments and not to dairy.

Except for Napier production, gender had no significant association with dairy technology adoption, meaning that both male and female household heads had an equal chance of adopting dairy, despite the fact that the women were less endowed in resources than the men. Men in LDCs have more resources than women (Adesina et al., 2000) and

this was quite evident (section 4.1), where men had more income and a higher access to labour and transport. Table 4.12 also shows that male household heads increased the probability of Napier production by 20%. However the interaction between gender and education shows that there was a negative correlation between Napier production and educated male household heads. This result shows that educated men would rather engage in other activities, probably off-farm than engage in dairy activities. Female headed households may adopt more than the male headed households if given if they had more resources.

A one-acre decrease in land size was associated with 0.2 % and 1% increase in the probability of IDB adoption and Napier production, respectively. As stated earlier in this thesis, land is only a constraint to livestock production if the household is highly dependent on it for feed. In such a case, a smaller land size would encourage cultivation of fodder that gives higher biomass per unit area. Indeed land pressure tends to increase land intensification, also leading to the widely held view that adoption of technologies that increase returns to land, labour or capital will only take place when factor proportions are constrained. This result also showed the households' failure to capture the economies of scale in dairy production, which arises from the fact that more land may mean more crop residue and even more natural pasture, factors that could lower costs per unit of production. About 28% of all the households had more land, (4.72(5.88)) acres, and an average income of at least Ksh 5,000. This is compared to an income of less than Ksh 5,000 for those households with less land (2.62(3.88), t=6.75). The conclusion from here, and also from the fact that off-farm income is not invested in dairy farming, was

that wealth was a necessary, but not a sufficient condition for adoption of dairy technologies, thus suggesting that there were underlying factors that conditioned adoption.

In terms of income sources, dairy farming ranked third amongst the households' farming activities, after cash and food crop production. Larger land sizes with a higher income attracted other farm activities but not dairy faming. There was cash crop production, where sugarcane and tea are the main cash crops. Therefore the hypothesis by Kaliba et al. (1997) that larger land sizes meant a lower probability of adoption of some technologies was true in this case. Dairy farming is only for smallholder farmers in the study area, a classic example of how farmers' priorities change with change in access to resources. However other studies (Nicholson et al., 1998; Staal et al., 2002) had found a positive correlation between land size and adoption of IDBs and Napier production.

Past experience with dairy technologies was associated with an increase in probability of 42% IDB adoption, 17% increase in the probability of anti-helminthics use, and 8% in Napier production. Households with past experience in dairy technologies are able to better control the risks in dairy farming by diagnosing and controlling diseases, and by giving the right kind of feeds. This emphasises the fact that dairy farming was a highly specialized kind of farming with a need for specialised experience.

Formal education of the household head was a significant factor in Napier production, where one year of education was associated with a 1% increase in Napier production. The

result here was interesting because extension did not increase Napier production, while education did. Non-significance of education in the adoption of the dairy breed and age in the adoption of all the three technologies means that age and education were not constraints to adoption, thus increasing the diversity of potential adopters.

Availability of extension services was associated with an increase in probability of 16% and 21% in IDB adoption and anti-helminthics use, respectively. There was no significant association between extension services *per se* and Napier production. However the interaction effect of extension and education was associated with a 1% increase in the probability of Napier production. This gives an indication that education is useful in understanding extension messages. The messages should therefore be passed in such a way that even the less educated understand and use the information. That specific knowledge on dairy farming, and not general farming knowledge on farming is quite critical in adoption of dairy technologies is evident from the significance of extension services and past experience to adoption. Intervention can therefore be done at the local level to improve extension that targets dairy development, as the government makes long term plans to reduce the literacy level, through the free primary education policy.

A PPE increase by an index of 0.1 gave a significant increase in the probability of adoption of IDBs and Napier production of 5.4%, and 9%, respectively. A high PPE lowers the cost of dairy farming because it encourages fodder production, which is relied on heavily in the study area, and also provides water for cattle. This finding depicts the actual situation in the LDCs because agriculture in the LDCs is highly vulnerable to the

whims of nature. It also indicated that some areas, like Rachuonyo, were considered unfavourable for adoption because of low PPE. Table 1-C (Appendix 1-B) shows that PPE was highly, but negatively correlated to the Luo ethnic factor, meaning that Rachuonyo, where the Luos are located had a low PPE. The household's close proximity to the tarmac road increased the probability of Napier adoption of 1%.

A high population density, which was a proxy for milk market access, was not accompanied by an increase in the probability of adopting IDBs, but increased the probability of Napier production by 2%. Only 22% of the households with cattle had milk for sale at the time of the survey. If it were assumed that this was the normal rate of the households with a marketable surplus, then one would expect that a high population density would increase the milk deficit, and therefore increase the probability of adoption. This was not so in the study area, leading to the conclusion that households' response to adoption of dairy farming to increased demand for milk in the neighbourhood was quite low. This could be due to some underlying constraints. This added to the justification for determination of the underlying factors influencing adoption analysed in section 4.3. The growing empirical evidence that livestock production occurs in areas with high demand for livestock products (Delgado et al., 1999; and Staal and Jabbar, 2000) was not found in the study area. Population pressure should create the need to intensify through the use of new technologies. The finding therefore was contrary to the Boserupian theory, which asserts that an increase in population pressure acts as an incentive to develop new technologies and produce more food.

A dependency ratio greater than 1 means a household had more dependants than household members who can work and be productive, and vice-versa. Therefore a household with a higher dependency ratio channels more resources to catering for dependants, hence lowers the capability to get more resources. Table 4.12 shows that a higher dependency ratio is associated with a decrease in the probability of adoption of IDB of 3%. This may be due to the time allocation between farm activities and looking after dependants, thus qualifying dairy farming as a labour intensive exercise. Taking care of young members of the household takes time, therefore households need to allocate time between taking care of dependants and working on the farm. However, hiring labour can mitigate the labour constraint, but the low incomes received in most households will hamper hiring of labour. In the study area, only 7% of the households said that children provide labour on the farm for livestock activities, and since hired labour was quite minimal, labour supply was mainly from the adults in the household. This is contrary to a study in Tanzania (Kaliba et al., 1997), which found a positive correlation between cattle stall-feeding and availability of male children in the household because children helped in stall-feeding cattle.

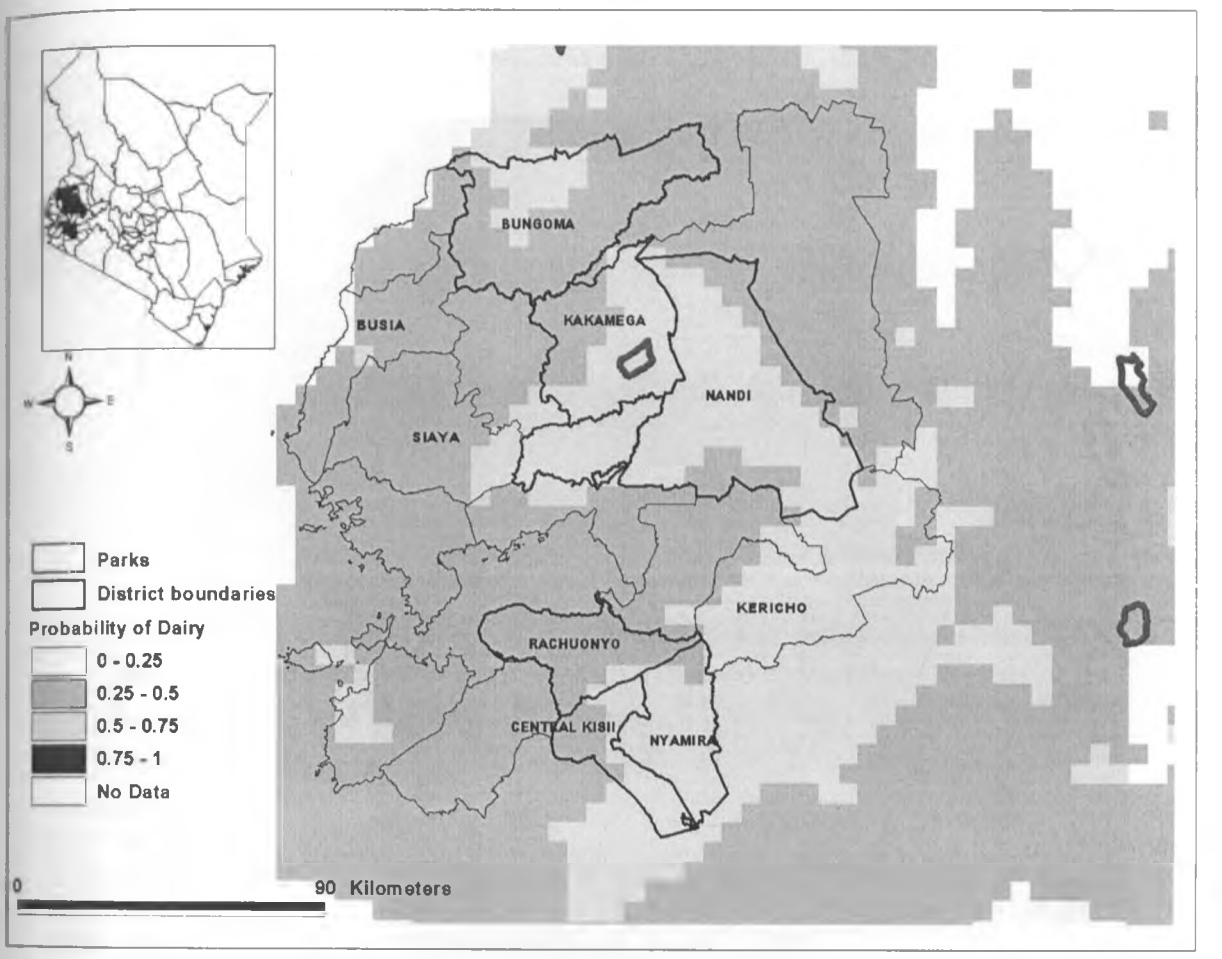
Ethnicity was significant in the adoption process, whereby the Kisii, relative to the Luhya were associated with an increase in the probability of 16% of adopting each of the three technologies. The Kisii, unlike the Luhya (Table 1-A, Appendix 1) may have attached more value to the economic than to the social benefits of rearing cattle. This was analogous with the finding by (Nicholson et al., 1998) that different ethnic groups with different cultures had different perception on technologies, where appropriateness of the

technology is determined by how the technology conforms to their cultures. Non-significance of the ethnic factor to adoption of anti-helminthics means that this is a technology that has been equally accepted across all ethnic groups in the study area.

Management, a factor that economists term as the fourth factor of production after land, labour, and capital (Ritson, 1977) was non-significant as shown in Table 4.12. This shows that there was very little difference between management of the farm by the household head and someone else. A higher entrepreneurship ability should have a higher allocative ability by increasing returns to household resources, but the low level of intensification shows that the management level is so low that it does not make a difference whether the farm owner is the manager or not.

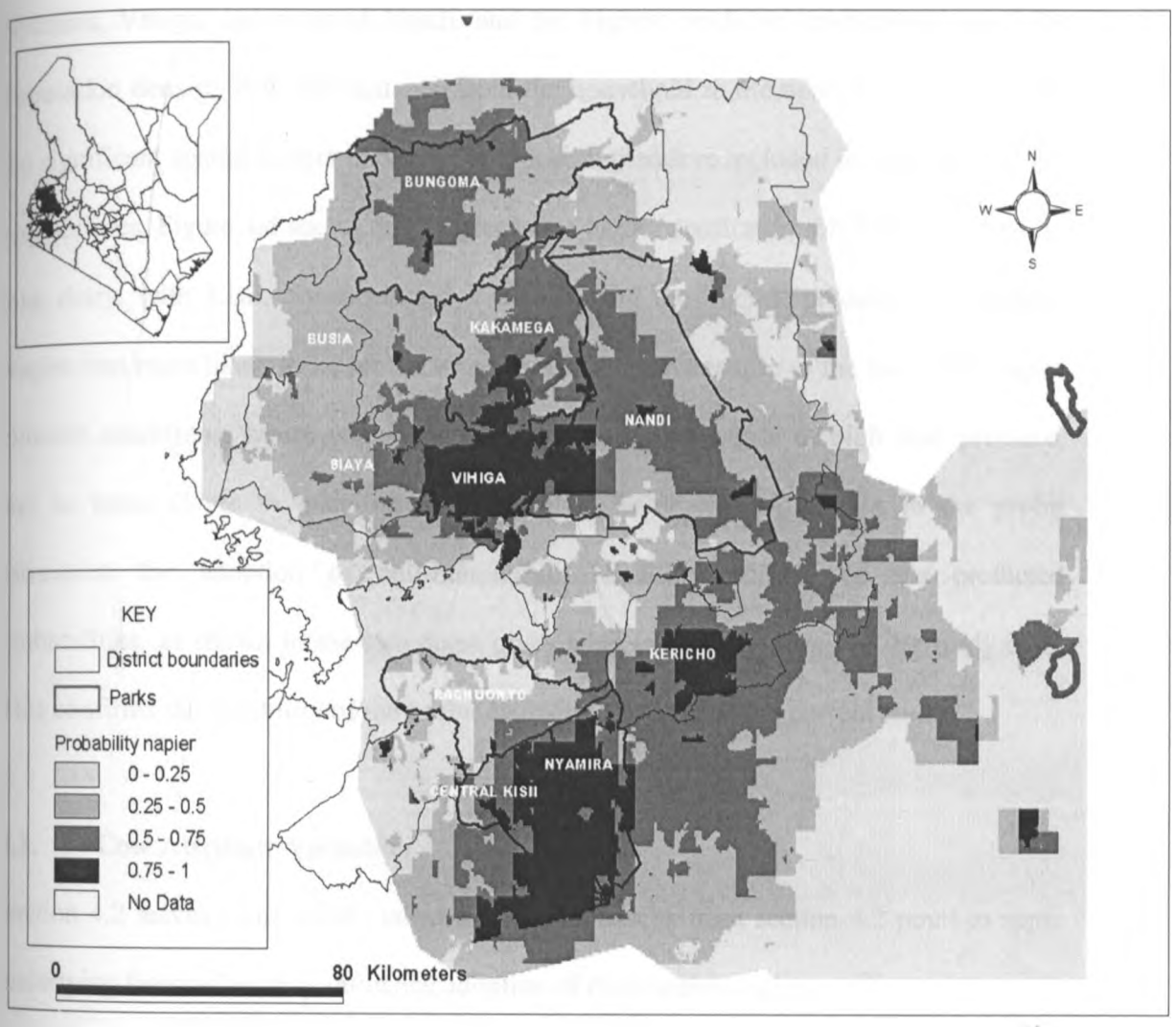
The spatial factors, namely PPE, population density, and distance from the household to the nearest main road, were the primary determinants of dairy technology adoption, and Figures 4.3 and 4.4 show predictions of probabilities of IDB adoption and Napier production respectively based on the spatial factors.

Figure 4.3 **A Map of Spatial Prediction of Probability of Adoption of IDBs, based on Parameter Estimates of GIS-derived variables by district**



Source: Author's Analysis

Figure 4.4 **A map of spatial prediction of probability of Napier Production based on Parameter Estimates of GIS-derived variables by District.**



Source: Author's Analysis

An explanation of how these maps were generated is in Appendix 1-N, Appendix 1. The non-spatial variables were held constant at their means during the prediction of the probabilities of adoption arising from the change in spatial factors. Figure 4.3 shows the predicted probabilities of dairy technology adoption based on PPE alone, because PPE

was the only spatial factor that was significant in the probit estimates. As expected the districts with the highest predicted probabilities of dairy technology adoption were Kisii, Nyamira, Vihiga, and parts of Nandi, and the highest predicted probability was 0.75. Population density, PPE and distance from the household to the nearest main road were the significant spatial factors in Napier production, therefore included in prediction of the probabilities. Figure 4.4 shows that Napier had a higher predicted probability of adoption than dairy, with Kisii, Nyamira, and Vihiga having the highest predicted probability. Napier was more likely to be grown where PPE was high because of the favourable agro-climatic conditions, where population density was high because of high land pressure, and in areas closer to main roads. No spatial factor was significant in the probit estimation for adoption of anti-helminthics. Spatial variation of the predicted probabilities, as shown in the two maps gives what is actually found in the study area. This confirms the reliability of the probit estimates obtained in the current study.

4.3. Cow Attribute Valuation

Section 4.2 leaves some results unexplained. The results from section 4.2 point to some underlying factors that may influence adoption of dairy technologies;

a) Non-significant positive association between adoption of dairy technologies and increase in population density. This shows households' low response to adoption of dairy farming as a commercial enterprise.

b) Wealth was a necessary but not a sufficient condition for adoption of dairy technologies

c) Variable adoption rates of the three dairy technologies are seen in Figures 4.2,

4.3, and 4.4. These variations across spatial and socio-economic factors show some underlying causes of the variations.

The binary choice model used in section 4.2 masks how households value different attributes embedded in the different breeds of the dairy cow. This is because in this model, the dairy breed is adopted or not adopted as a composite of many attributes, making it difficult to know which attribute contributed to the decision to adopt or not to adopt. In the current study, the cow was the only technology chosen for attribute valuation because its attributes have a direct implication on the use of the other two technologies (Napier production and the use of anti-helminthics) considered in the study. The valuation was done in order to quantify the economic trade-offs made during adoption of dairy technologies, assess resource availability, households' perceptions of dairy technologies and their farming priorities. This was necessary to understand the adoption patterns of dairy technologies observed and suggest interventions to increase adoption of dairy technologies. The cow attributes were, milk yield, disease resistance, and feed requirement.

Utility of a given cattle breed is a function of the characteristics of the breed, the individual's characteristics, and the interaction between the individual's socio-economic background and the attributes of cattle (Sy et al., 1994). The OPM was applied to capture this functional relationship, with rankings as the dependent variable, while attribute levels, and household characteristics were the independent variables.

Two attributes, milk yield and price of the cow were recorded as continuous variables,

while feed requirement and disease resistance were effect-coded, thus making coefficients marginal values. The effect-coding system dictates that all the coefficients should add to 0 (Tano et al., 2003) and they enable direct measurement of marginal changes in the dependent variable as a result of a unit change in the independent variable. Table 4.13 gives a summary of the household characteristics thought to influence the valuation of the four attributes.

Table 4.13 A Summary of all the Variables Influencing Valuation of Attributes

Continuous Variables	Variable Description	Mean	SD	Minimum	Maximum	n
age	Age of the household head in years	51.40	14.19	22	93	630
education	Education of the household head in years	7.74	4.40	0	18	630
Lnd	Land size of the households in acres	4.04	5.12	0	63.5	630
hhN	Number of household members	6.67	2.74	0	23	630
ppe	Precicipitation over evapo-transpiration	1.05	17	0.73	1.35	625
popn	Population density (persons per km^2)	630	406	124	1648	604
TNU3	Distance to the nearest urban center in km	2.02	2.61	0	12.31	625

Categorical Variables	Variable description	1 (%)	-1 (%)	n
gender	1=Male, -1=Female	79	21	630
trd	1=households that value the Zebu for bride price, gifts, and social status, -1=Otherwise	17	83	630
kisii	1=Kisii household heads, -1=Otherwise	26	71	630
Nandi	1=Nandi household heads, -1=Otherwise	10	90	630
Luo	1=Luo household heads, -1=Otherwise	15	85	630
Luh	1=Luhya household head, -1=Otherwise	48	52	630
dairy12	1=had dairy 12 years ago, -1=Otherwise	30	70	630
trans	1=had transport, -1=Otherwise	64	36	630
labour	1=had hired labour, -1=Otherwise	61	39	630
OfffarmYRank	1=had off farm income, -1=Otherwise	34	66	630
EXXT	1=received extension on livestock, -1=Otherwise	39	61	630
hINC	1=income more than Ksh 5,000, -1=Otherwise	37	63	630

There was a wide variation in the population density, PPE and age across the sampled households. The data also shows a smaller population of households with an income of more than Ksh 5,000, those with off-farm income, and those that received extension services. After the PC analysis on the variables in Table 4.13, the independent variables

retained (Table 1-C, Appendix 1) were; the household head, income of the household, preference for cattle for traditional practices, PPE, whether off-farm income is the main source of income or not, education, and ethnicity of the household head (Nandi and Kisii). For categorical variables, code 1 represented the presence of that variable in an observation while -1 represented its absence. The general hypothesis was that household characteristics influenced valuation of the attributes. Valuation of the attributes was first done irrespective of the households' socio-economic characteristics (a typical household), and then household characteristics included in the second model. The households' diversity of socio-economic characteristics in the study area was a good basis for their inclusion in the model because different households value the attributes differently. Table 4.14 shows OPM estimates with attribute levels only as independent variables.

Table 4.14 The Ordered Probit Estimates and Attribute Values from a Typical Household

Threshold levels	Coefficient	Marginal WTP/WTA (Ksh)
γ_1	-.13(0.18)	
γ_2	0.62(0.18)	
γ_3	1.32(0.18)	
γ_4	2.18(0.18)	
Attribute levels		
Low disease resistance	-0.32 (0.03)***	-16,000
Price	-.00002 ($2.46(10^{-6})$)***	
Milk yield	0.17 (0.005)***	8,500
Low feed requirement	0.09 (0.03)***	4,500
High feed requirement	-0.30 (0.03)***	-15,000
High disease resistance	-0.02 (0.03)	
B1	-0.00(0.04)	
B2	0.020 (0.04)	
B3	0.03 (0.04)	
B4	-0.001 (0.04)	
B5	-0.07 (0.04)	
B6	0.043 (0.04)	
B7	-0.01 (0.04)	
B8	0.01 (0.04)	
LR	1707***	
No. of observations	3146	
Degrees of freedom	14	

Source: Author's Analysis

*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level**

Values in brackets are standard errors

The threshold levels (γ_i) are coefficients that link profile rankings to utility. The OPM follows the cumulative standard normal distribution. The LR for both models was significant at 1% level, indicating the relevance of the independent variables in explaining variations in preferences. Apart from the high disease resistance attribute, all

other coefficients were significant with the expected signs. Significance of the coefficients means that the attribute levels were significantly different from the default category, which in this case was the medium level of each attribute studied. These coefficients show marginal utility. Marginal utility is the change in utility obtained from a bundle of goods when the level of one of the goods changes, as the levels of other goods in the same basket remain constant (Varian, 1987). In the current study, a bundle of goods is referred to as the profile of attributes. The positive and significant coefficient of the milk yield attribute, which means positive marginal utility, shows that households gave a higher rating to the profile with higher milk yield than the one with a lower milk yield. Conversely, the negative and significant price coefficient, which means negative marginal utility, shows that households gave a lower rating to the profile with higher price than the one with a lower price. All the blocks were not significant with reference to the default (Block 9).

From the explanation given in Chapter II section 2.3, dividing the attribute level coefficient by the price coefficient, and getting the negative of the result gives the marginal WTP/WTA values. Positive values mean WTP for an attribute, while negative values mean marginal WTA compensation to keep an attribute. The value Ksh 8,500 is what households are willing to pay to have a cow with a higher milk yield. This amount is almost the same as the difference between the observed price of the Zebu and the Dairy Cross, but less than the actual price difference between the Dairy Cross and the High Grade cow. This makes it easier for households to move from having a Zebu to a Dairy Cross than from a Dairy Cross to a High Grade breed. This explains why the study area

had more Dairy Cross than High Grade breeds (households with High Grade breeds were not more than 7%, while those with Dairy Cross breeds were 46%). The observed price of the Zebu was between Ksh 4,000 and Ksh 8,000, that of the Dairy Cross was between Ksh13, 000 and Ksh 15,000, while the price of the High Grade was between Ksh25, 000 and Ksh 30,000. The marginal WTP for low feed requirement was Ksh 4,500. A typical household is willing to pay more for a cow with higher milk yield than one with lower feed requirement. This ranks milk yield as the most important attribute, followed by feed requirement and lastly disease resistance. A typical household is willing to take a compensation of Ksh 15,000 to accept a cow with high feed requirement and Ksh 16,000 to have one with low disease resistance. This means that they are more averse to diseases than to high feed requirement. The marginal WTP for a low feed requirement was Ksh 4,500, while the marginal WTA compensation to have a cow with high feed requirement was Ksh 15,000. This is because households are not sure of feed availability if they had a cow with high feed requirement, therefore they would want to be compensated Ksh 15,000 for the lower utility. The measures of WTP and WTA can only be equal in a perfectly competitive environment (Markandya, 2000). In the current study, lack of knowledge of the existing feed resources causes a much higher WTA, and if there was more awareness (information) about feed resources, then this value would be closer to the WTP value.

It is important to look at how households trade-off milk yield for other attributes. This is because milk yield is the most important attribute, and in practice an individual's decision to adopt a certain breed is based on trade-offs among attributes. The MRS of milk yield

for high disease resistance is;

$$-\frac{(-0.32)}{0.17} = 1.88 \text{ litres.}$$

This means that, other attributes constant, a typical household traded off 1.88 litres of milk per cow per day for higher disease resistance. A typical household also traded off;

$-\frac{(-0.30)}{0.17} = 1.76$ litres of milk per cow per day, for a cow with lower feed requirement.

The trade-offs show the amount of milk forgone per day when households rear the Zebus instead of the IDBs. These figures show that an IDB gives a marginal benefit of 3.64 (1.88 +1.76) litres of milk per cow per day with more feed and control of diseases. These trade-offs for a typical household were compared with trade-offs from different categories of households.

The real power of conjoint analysis is seen when household characteristics are considered in attribute valuation (Baidu-Forson et al., 1997). A separate OPM was run with interactions of the households' characteristics and attribute levels as independent variables, in addition to the independent attribute levels and the blocks. Table 4.15 shows the significant interactions.

Table 4.15 The Ordered Probit Estimates and Attribute Values from the Interactions of Cow Attributes and Household Characteristics

Interactions	Coefficient	WTP/WTA (Ksh)
Milk yield•Kisii	0.10 (0.01)***	3,333
Milk yield•trd	-0.03 (0.01)***	-1,000
Milk yield•Nandi	0.08 (0.02)***	2,666
Milk yield•high PPE	0.03 (0.01)***	1,000
Price•high PPE	0.00002 (5.59(10^{-6})***	
Extension•milkyield	0.02 (0.01)**	666
Low feed requirement• Kisii	0.31 (0.16)**	10,333
Low feed requirement• Nandi	0.64 (0.22)***	21,333
Low feed requirement• off-farm income	-0.50 (0.13)***	-16,666
High feed requirement• high PPE	-0.25 (0.13)*	8,333
High feed requirement•off-farm income	-0.39 (0.13)***	-13,000
High feed requirement•Education	0.03 (0.01)***	2,000
High disease resistance•off-farm income	0.29 (0.14)**	9,666
Low disease resistance•off-farm income	-0.23 (0.13)*	-7,666
Low disease resistance•high PPE	-0.23 (0.13)*	-7,666
LR	1938***	
No. of observations	3126	
Degrees of freedom	59	

Source: Author's Analysis

*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level, and • means interactions.**
Values in brackets are standard errors

The significance of interaction effects means that household characteristics substantially influenced attribute valuation, and that households can be segmented along the significant characteristics, while no significance means different groups do not value the attributes any differently from the typical household. The marginal WTP for an attribute for a specific household characteristic was obtained by summing up the main effect marginal WTP attribute values in Table 4.14 and the marginal WTP attribute value arising from the interaction between that attribute and that specific household characteristic, as shown in Table 4.15. This sum will show attribute preference for a particular category of households.

Factors that influenced valuation of attributes were PPE, extension services, Kisii, and Nandi, off-farm income, education, and cultural values. The marginal WTP for milk yield for a household in Kisii was Ksh 11,833 (8,500+3,333), while the marginal WTP for milk yield for a household in Nandi was Ksh 11,166 (8,500+2,666). Households located in areas with a PPE greater than one increased the marginal WTP for high milk yield by Ksh 1,000 (an increase from Ksh 8,500). They traded off 2.75 litres of milk per day [(-0.32+-0.23)/ (0.17+0.03)] for a cow with high disease resistance, and 2.75 litres of milk per day [(-0.25+-0.30)/ (0.17+0.03)] for a cow with a lower feed requirement. The high milk trade-off for disease resistance is justified because a high PPE is accompanied by high disease incidences, making such households sensitive to disease resistance. However the trade-off for low feed requirement is unexpected because areas with high PPE have the potential to grow more fodder than those with a lower PPE. This leads to the conclusion that households in high PPE areas do not fully exploit the opportunity to grow more fodder.

Households that received extension services are willing to spend an additional Ksh 666 (in addition to Ksh 8,500) on a cow with a higher milk yield. When comparing the marginal WTP for households that have received extension services with the marginal WTP from households with other household characteristics, it shows that extension is not doing enough to promote improved dairy technologies. For instance, the Kisii would spend an additional Ksh 3,333, while the Nandi would spend Ksh 2,666 more to have a cow with high milk yield. This shows a higher preference for, and hence the prevalence of IDBs in Kisii and Nandi. The result also apportions the efforts made by different stakeholders in

the adoption of dairy technologies.

The Kisii and Nandi had a higher WTP for milk yield than the typical household, their WTP for low feed requirement is higher than that of milk yield. The Kisii are willing to pay an additional Ksh 10,333 for a cow with low feed requirement while the Nandi would give up twice that amount. This result is to be expected among the Kisii because they have small parcels of land, which makes fodder availability more difficult. Most households in the study area rely on fodder from the farm. The high marginal WTP for low feed requirement therefore indicates scarcity of land in Kisii. The high marginal WTP in Nandi may mean that households in this area would not want to expand their area under fodder at the expense of other enterprises. This means that the Nandi had a higher opportunity cost for land. This result and the one from the interaction of PPE and high feed requirement show that extension should emphasise the different sources of feed and feed preservation methods. Household heads with a higher education level had a marginal WTP for a cow with high feed requirement. This is not surprising because a higher level of education increases the ability to identify more sources of fodder. Furthermore Table 4.12 shows that education increases the probability of Napier production by 1%.

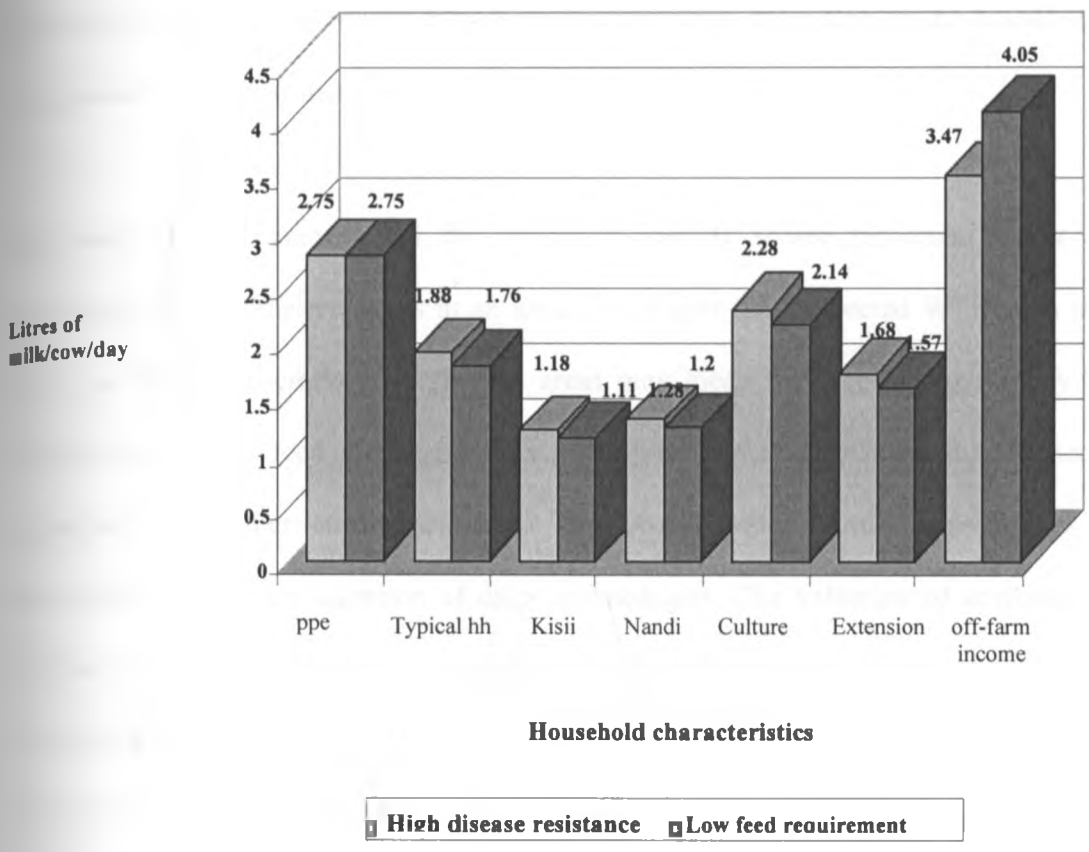
The Kisii would trade off 1.11 litres (-0.30)/ (0.17+0.1), while the Nandi would trade off 1.2 litres (-0.30)/ (0.17+0.08) of milk for a cow with a low feed requirement. These trade-offs are lower than for the typical households hence the prevalence of the Dairy Cross in these areas. Households that valued cattle for cultural functions (trd) had a WTA of Ksh 1,000 as compensation for having a cow with high milk yield as compared to a typical

household. This shows that they valued milk yield less than the typical household, giving an indication that they did not rear cattle with the main objective to have a significant marketable surplus. The preference for quantity, and not quality in order to meet their cultural needs, as also noted by (Waithaka et al., 2002), brings to the fore a trade-off between maximising production and utility. This preference decreased the probability of adopting the IDB's. This was an indication that personal characteristics influenced movement from the economic objectives of rearing dairy to accommodate other objectives. This explains, in part, why households that uphold cultural functions like paying dowry keep either the Zebu alone or have both the Zebu and the IDBs.

With reference to the medium feed requirement, households with off-farm income as their main source of income had a marginal WTA compensation of Ksh -28,000(-15000+-13,000) for a cow with a higher feed requirement. This category of households also had a marginal WTA of Ksh -23,666 (-16,000+-7,666) for a cow with low disease resistance. The WTA for low disease resistance and high feed requirement is higher than for a typical household, and this explains why this category of households does not rear the IDB, hence the negative association with adoption of the IDB as shown in Table 4.12. The high management levels for the High Grade breeds do not allow this category of households to keep High Grade breeds because they do not spend most of their time on the farm.

Figure 4.5 shows the milk trade-off pattern across different characteristics with reference to the typical household.

Figure 4.5 Milk trade-offs for other attributes



Note: hh means household

Kisii and Nandi show lower trade-offs than the typical household. Extension shows trade-offs that are almost the same as for the typical household, while PPE, culture and off-farm income show high trade-offs than the typical household.

What is evident from the results in Table 4.15 is that households in the study area wish to be market oriented through increasing their milk yield. The different marginal WTP values from different household categories show that dairy attribute values are different for different household groups. The different marginal WTP values together with the

milk trade-off pattern in Figure 4.5 explain the adoption patterns seen in the study area. Therefore adoption of improved dairy technologies varies depending on the households' circumstances and priorities.

This analysis has demonstrated the ability to identify scarce resources and/or the opportunity cost of the resources in an area. The higher than expected WTP for a cow with low feed requirement in high PPE areas may mean the inability to identify the different sources of feed that come with high PPE. It may also mean that fodder is competing with other crop enterprises. This analysis also shows opportunities of intervention to increase adoption of dairy technologies. The valuation of attributes by different households indicates the contributions made by household characteristics and the household environment in the adoption of dairy technologies. Therefore this gives a pointer to the interventions to be made to increase adoption of dairy technologies.

Chapter V

Summary, Conclusions and Recommendations

5.1. A Summary

The trends in the global supply and demand of livestock products in the LDCs and DCs show that increasing domestic production in the LDCs is the way to go. The dairy sector, which contributes substantially to livelihoods in the LDCs, shows variable adoption rates of dairy technologies. Western Kenya, one of the areas that show low adoption rates of dairy technologies is a milk deficit area. This area exhibits higher poverty levels than some other parts of Kenya. Crop husbandry dominates in Western Kenya, with cash crops offering low and unreliable income. In addition the soils have very low soil fertility. Different studies have shown that smallholder dairy has the potential to increase; income (especially for women), employment, soil fertility through crop-livestock integration, and the households' nutritional status. Adoption of dairy technologies in Western Kenya is the way to go. The areas high population growth rate in the study area means that the nutritional requirements of these people need to be met. In addition there is a high potential for dairy technologies in most parts of the area yet there are very low adoption rates in most parts of the country. Therefore the factors affecting adoption of dairy technologies need to be addressed.

Before any study on adoption is done, understanding the adoption patterns and factor relationships in technology adoption is important. This is because different technologies exhibit different characteristics in different circumstances. In addition analytical models used in adoption depend on factor interrelationships and the technology adoption

patterns. The various factors that influence adoption can be divided into technology, farm and household characteristics, and spatial factors.

Consumer theory is the theoretical underpinning of most adoption studies, therefore the analytical models were pegged to the theory. The analytical methods were descriptive statistics, revealed preference and stated preference (conjoint) methods. The model used for revealed preference was the binary choice probit model, and it was guided by the traditional consumer theory. The new consumer theory guided the use of Conjoint analysis. The CJ is an SP method that was used for cow attribute valuation. The OPM was used to get the MRS, WTP, and WTA measures. These measures were used to measure valuation of cow attributes by different households.

The objective of the study was to investigate the factors affecting adoption of dairy technologies in western Kenya. Two-cross-sectional data sets were used in the current study. The first dataset consisted of 1575 households from seven districts, while second dataset consisted of 630 households, from five of the seven districts selected.

Descriptive statistics showed variations in spatial, socio-economic, and institutional factors across the districts. The key factors influencing adoption of dairy technologies were; experience in using dairy technologies, extension services, PPE, land size, dependency ratio, income and ethnicity. Gender was not a factor in adoption of the dairy breed despite the widely acknowledged gender differences in resource endowments.

The marginal WTP values from CJ analysis showed milk yield as the most important attribute, followed by feed requirement and disease resistance. That household characteristics condition the valuation of cow attributes was quite evident in the results. Education, extension, off-farm income, the ethnic factor, and households that preferred the Zebu for cultural purposes were determinants in the valuation of cow attributes.

The current study makes a substantive contribution to the knowledge of adoption, through a consistent analytical framework. The analysis starts with a description of the study area, followed by factor inter-relationships where the study first identified the constraints to dairy, then verifications and explanations of these relationships through attribute valuation, making a comprehensive analysis of dairy technologies in the study area.

5.2. Conclusions

The null hypothesis that socio-economic factors of the households and spatial factors do not influence the valuation of different cow attributes, and consequently do not influence the adoption of dairy technologies is not accepted. The factors that were associated with adoption of the three dairy technologies were land size, income, PPE, population density, extension services, gender, education, experience with the use of dairy technologies, and ethnicity of the household head. The PPE was the main spatial factor positively associated with adoption of the IDBs. Population density was positively associated with Napier production and not IDBs. Mapping of the spatial factors is useful for easier location of areas for intervention and simulations. The association of income, land size and population density with adoption of dairy technologies unveils a unique adoption

process in the study area. It is only on-farm income, and not off-farm income that is invested in dairy development. In addition credit was not identified as a constraint in the adoption process. That large land sizes are not associated with dairy development shows that dairy is only for smallholder farmers in the study area. Increase in population density (which in the current study was a proxy for market access) was not associated with increase in the adoption of IDBs. This shows that most of the households show limited market orientation in dairy production. All these unique findings showed some underlying factors associated with dairy development.

The household characteristics that influenced valuation of cow attributes were off-farm income, precipitation over evapo-transpiration (PPE), ethnicity, cultural values, education, and extension. In reference to the typical households, household characteristics that showed a higher marginal WTP for a cow with low feed requirement implied either scarcity of feed, high opportunity cost of using land for fodder or lack of information on feed resources. A higher marginal WTP for a cow with high milk yield gave an indication of the households' priorities. A marginal WTA payment for a cow with high milk yield in the face of potential markets showed different farming priorities and lack of information. A marginal WTA payment for a cow with low disease resistance shows risk aversion and limited information on disease control.

Analysis of all the factors that determine adoption of dairy technologies shows information to be the main determining factor in adoption of dairy technologies. Past experience with the dairy technologies, extension and education are all sources of

information. Past experience shows a stronger association than extension services. In the CJ analysis, lack of adequate information on feed resources is evident. This is shown through high marginal WTP and high milk trade-offs for a cow with low feed requirement. This was to the extent that households in high PPE areas still perceived scarcity of feed as a major constraint. Extension services have played a key role in the adoption of IDB's and the use of anti-helminthics, but their role in giving information on feed resources, and how different feeds can increase milk yield has been quite minimal as is evident in Figure 4.5. As long as there is still lack of information on how the easily available fodder can be utilised and preserved during feed shortages for increased milk yield, the Zebu is bound to prevail for a long time because it requires less feed. Educated household heads have the ability to get information on dairy technologies, therefore are more likely to adopt the technologies than those household heads without education.

Cultural factors are also highly associated with adoption of dairy technologies. This is manifested in the adoption patterns according to ethnicity, gender and traditional practices. Lastly household priorities influence adoption because households with off-farm income as the main source of income and the households with more land are less likely to invest in dairy farming. The educated male household members do not invest in dairy farming. These factors show that resource availability alone is a necessary but not sufficient to increase adoption.

The RP and SP methods complement the analysis in adoption of dairy technologies. The RP methods determine the factors influencing adoption. The SP methods explain the

underlying factors that determine the interrelations in adoption and the implications during adoption. The SP method also enables the assessment of a technology by researchers, thus giving feedback signals to researchers to either incorporate the relevant attributes, or address factors that influence the households' valuation of attributes that influence adoption. This analysis therefore demonstrates the bottom-up approach to research.

5.3. Recommendations

An individual cannot be brought out of poverty unless the quality and productivity of the resources on which that livelihood depends are addressed. Interventions to promote dairy technology adoption should exploit the opportunities available and address the circumstances under which decisions are made. The specific recommendations are;

a) The Government of Kenya should take the lead in giving information because the stage of dairy development in the study area is very low. This is because the former has the infrastructure established in the form of extension agents. In addition information on dairy technologies is a public good in the study area because of the low developmental stage in dairy farming, therefore still unattractive to the private sector. Once awareness of the potential benefits from dairy has increased and the adoption rates increase, the government should then encourage the private sector to invest in availing information and provide services. The private sector can then realise returns from their investments once adoption rates increase

b) High on the agenda of extension programmes should be the crop-livestock integration projects. Households should take advantage of the low opportunity cost of labour to increase the competitiveness of dairy among other farming enterprises. Because dairy was still at a low capital level in most parts of the study area, labour-led intensive technologies, like the use of manure and cut-and-carry fodder can take the lead. This starts a step-by-step self-propelling mechanism that will increase overall farm production, thereby generating more capital for intensification of dairy farming. Thus the productivity potential of existing resources should be exhausted before moving to additional resources.

c) Households in Kakamega, Vihiga, Bungoma, and Rachuonyo need more emphasis on production than marketing issues. More emphasis on marketing than production should be made in Nandi through the recognition of the informal milk marketing channels, encouraging farmers to form marketing groups and learn new and hygienic methods of preserving and marketing milk. Although Kisii and Nyamira Districts had more than 50% of the households with at least one of the technologies (Figure 4.2), they need to rapidly increase milk production because of their high population density.

d) The current study shows that households with dairy cattle acquired them from neighbours, indicating that diffusion of technologies can be faster through neighbours. Farmer groups therefore form the best fora for intervention. Due to limited resources in terms of infrastructure, capital, and extension staff, and due to

the risk-averse attitude and cultural rigidities, households can be organised in groups for faster, cost-effective flow of information, and even for support and encouragement from one another. Through these groups the various bottlenecks causing high-risk aversion and low valuation of milk yield, can be addressed. Women groups, an infrastructure that is already in place, should seek more recognition, be more organised and focused in their objectives. Extension agents should encourage farmers to join Farmer Field Schools (FFS). The FFS groups in the western part of Kenya should put adoption of dairy technologies high on their agenda. The groups should write proposals with the following objectives;

i. To provide rain water-harvesting technologies and sink boreholes,
ii. To avail more information on the use of fodder,
iii. To alleviate women's constraints for increased adoption of dairy technologies and enable women to have control of the benefits.

The proposals should highlight what inputs the farmer groups will give before The farmers can approach donors for assistance.

e) It has been established from the current study that households with off-farm income have higher income than farm income, meaning that the government should make efforts to create opportunities for off-farm income. Dairy farming is being advocated as a strategy in the broader perspective of development, and policy interventions should touch the entire dimension of the agricultural system. Alongside the development of agriculture the Government of Kenya should

encourage the private sector to develop the non-agricultural sector in order to increase people's income and diversify out of agriculture in the long run. This is because demand for livestock products is income elastic. Increased incomes will also move the households' economy from labour intensive to capital-intensive dairy farming.

f) The current study does not solve all dairy related problems suggested in this study. There is an urgent need for a study on the identification and preservation of various feed sources in western Kenya.

References

Adamowicz W., Louviere J., & Williams M. (1994). Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities. Journal of Environmental Economics and Management 26, (1994) 271-292. Academic Press Inc.

Adesina, A.A., & Baidu-Forson. (1995). Farmers perception and adoption of new agricultural technology: Evidence from analysis in Burkina Faso and Guinea-West Africa. Journal of Agricultural Economics 13 (1995) 1-9. Elsevier Science Publishers.

Adesina, A.A., Mbila, D., Nkamleu, G.B., & Endamana, D. (2000). Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. Journal of Agriculture, Ecosystems and Environment 80 (2000) 255-265. Elsevier Science Publishers.

Adesina, A.A., & Zinnah, M.M. (1993). Technology characteristics, farmers perceptions and adoption decisions: A Tobit model application in Sierra Leone. Journal of Agricultural Economics, 9 (1993) 297-311. Elsevier Science Publishers.

Ayalew, W., King, J.M., Bruns, E., & Rischowsky. (2003). Economic evaluation of smallholder subsistence livestock production: lessons from an Ethiopian goat development program. Journal of Ecological Economics 45 (2003) 473-485. Elsevier Science Publishers.

Baidu-Forson, J., Ntare, B.R., & Waliyar, F. (1997). Utilizing Conjoint Analysis to design modern crop varieties: Empirical Example for Groundnut in Niger. Journal of Agricultural Economics16 (1997) 219-226. Elsevier Science Publishers.

Baidu-Forson. (1999). Factors influencing adoption of land-enhancing technology in the Sahel: lessons from a case study in Niger. Journal of Agricultural Economics 20 (1999) 231-239. Elsevier Science Publishers.

Batz, Franz-Josef. (2000). Improving Priority Setting for livestock Research by using Technology Characteristics for Adoption Assessment. A PhD Dissertation. Berlin, Humboldt-University.

Bebe, B.O. (2003). Herd dynamics of smallholder dairy in the Kenya highlands. A PhD Thesis, Wageningen University, The Netherlands. ISBN: 90-5808-788-3

Ben-Akiva, M., & Lerman, S.R. (1985). Discrete Choice Analysis: Theory and Application to Travel Demand. MIT Press Series in Transport Studies, Cambridge, Massachussetts. London, England.

Benedicte de la Briere. (2000). Imperfect food markets and Household Adoption of soil Conservation Practices in the Dominican Republic Highlands: Household Probit and Duration Models. In N. Heerink, H. Keulen, & Kuiper M. (Eds.), Economic Policy and sustainable land use. Recent Advances in Quantitative Analysis for Developing

Countries. Physica-Verlag.

Brown, L.R., Feldstein, H., Hadda L., Pena C., & Quisumbling A. (2001). Generating Food security in the year 2020. In P. Pinstrip-Anderson & R, Pandya-Lorch (Eds.), The Unfinished agenda. Perspectives and Overcoming Hunger, Poverty and Environmental Degradation. International Food Policy Research Institute.

Casey, J.F. (2000). Conjoint Analysis of Farmer Preferences for Agroforestry In Calakmul, Campede, Mexico, In The Handbook of Contingent Valuation. Edward Elgar Publishers. Mexico.

Cattin, P., & Wittink, D.R. (1982). Commercial use of conjoint Analysis: A survey. Journal of Marketing. Vol. 46 (Summer 1982), 44-53.

Delgado, C., Rosegrant, M., Steinfield, H., Ehui, S., & Courbis, C. (1999). Livestock to 2020. The Next Food Revolution. Food, Agriculture, and the Environment Discussion Paper 28. IFPRI. Washington D.C.

Feder, G., Ejustand, R., & Zilberman, D. (1985). Adoption of Agricultural Innovation in Developing countries. A survey. World Bank staff working papers Number 542. TheWorld Bank Washington D.C, U.S.A.

Gan, C., & Luzar, J.E. (1993). A Conjoint Analysis of Waterfowl Hunting in Louisiana. Journal of agriculture and applied Economics 25(2) December, 1993: 36-45.

Greene, W.H. (2000). Econometric Analysis. Fourth Edition. Prentice Hall International, Inc.

Green, P., & Srinivasan, V. (1990). Conjoint Analysis in Marketing New Developments With Implications for Research and Practice. Journal of Marketing, October 1990.

Green, P. (1974). On the Design of Choice Experiments Involving Multifactor Alternatives. Journal of Consumer Research. Vol. 1. September 1974.

Gujarati, D.N. (1995). Basic Econometrics. Third Edition. McGraw-Hill International Editions.

Hensher, D.A. (1994). Stated Preference Analysis of Travel Choices: The state of Practice. Transportation 21: 107-133. Kluwer Academic Publishers. Netherlands.

Holden, S.T., Taylor, J.E., & Hampton, S. (1998). Structural adjustment and market imperfections: a stylised village economy-wide model with non-separable farm households. Journal of Environment and Development Economics 4 (1998) 69-87. Cambridge University Press.

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

Jama, B., Amadou, Niang, I., Joris De Wolf, Amadalo, B., & Rao, M.R. (1998). Sources of nutrient-depleted soils of western Kenya. Paper presented in the sixth Eastern and Southern Africa Regional Maize Conference, 21st -25th, September 1998 pp 235-241.

Kaliba, A., Featherstone, A.M., & Norman, D.W. (1997). A stall-feeding management for improved cattle in semiarid central Tanzania: Factors influencing adoption. Agricultural Economics, Volume 17, Issues 2-3, December 1997, Pages 133-146 Elsevier Science Publishers.

Kaliba, A., Verkuijl, H., Mwangi, W., Aandajaayasekeram, P., & Moshi, A. (1998). Factors affecting adoption of maize production technologies in central, Eastern and western Tanzania. Paper presented in the sixth Eastern and Southern Africa Regional Maize Conference, 21st -25th, September 1998 pp 375-379.

Kariuki, J. (1998). The potential of improving Napier grass under smallholder dairy farmers conditions in Kenya. A PhD Thesis. Landbouw Universiteit Wageningen.

Karugia, J.T. (1997). Quality Factors Affecting the Value of Beef in Kenya: An Assessment of Relevant Attributes and Alternative Methods. A PhD Thesis in Agricultural economics. Department of Rural Economy. Edmonton, Alberta.

Kenya Government. (2000). Economic survey. Central Bureau of statistics. Ministry of Planning and National Development. Government Printers, Nairobi.

Kenya Government. (2003). Economic survey. Central Bureau of statistics. Ministry of Planning and National Development. Government Printers, Nairobi.

Koutsoyiannis. (1977). Theory of Econometrics. An Introductory Exposition of Econometric Methods. Second Edition. Macmillan Education Ltd. London.

Kuhfeld, W.F., Tobias, R.D., Garrant, M. (1994). Efficient Experimental Design with marketing Research applications. Journal of Marketing Research. Volume XXX1, 545-557.

Kuriyama, K. (1998). Estimation of The Environmental Value of Recycled Wood Wastes: A conjoint Analysis study. Prepared for presentation at the annual meetings of the Japanese Forest society, April 2-4, 1998, Utsunomiya University, Utsunomiya.

Kuyvenhoven, A., Ruben, R., & Kruseman, G. (1998). Technology, market policies and institutional reform for sustainable land use in southern Mali. Journal of Agricultural

Economics, Volume 19, September 1998 (53-52). Elsevier Science Publishers.

Lapar, M., & Pandey, S. (1999). Adoption of soil conservation: The case of the Philippine uplands. Journal of Agricultural Economics 21 (1999) 241-256. Elsevier Science Publishers.

Lazari, A.G., & Anderson, D.A. (1994). Design of Discrete Choice Set Experiments for Estimating Both attribute and Availability Cross Effects. Journal of Marketing Research Vol. XXX1 (August 1994), 375-383.

List, J.A. (2004). Substitutability, experience, and the value disparity: evidence from the marketplace. Journal of Environmental Economics and Management.Volume 47, Issue 3, May, 2004, Pages 486-509.

Mackenzie, J. (1992). Evaluating Recreation Trip attributes and Travel Time Via Conjoint Analysis. Journal of Leisure Research, 1992. Vol 21. No. 2. pp 171-184.

Mackenzie, J. (1993). A comparison of contingent preference models. American Journal of Agricultural Economics 75 August 1993 (503-603).

Markandya, A. (2000). Methods for valuation of impacts of hydropower. Department of Economics, University of Bath. One of the 126 contributing papers to the world commission on dams. http://www.dams.org/docs/kbase/contrib/eco072.pdf

Muriuki, H.G. (2002). Smallholder dairy production and marketing in Kenya. In D. Rangnekar & W.Thorpe (Eds.), Smallholder Dairy production and marketing opportunities and constraints. Proceedings of a south-south workshop held at National Dairy Development Board, Anand, India, 13-16 March 2001. NDDB, Anand, India, and ILRI, Nairobi. Kenya, 538pp.

Negatu, W., & Parikh, A. (1999). The impact of perception and other factors on the adoption of agricultural technology in the Moret and Jiru Woreda District of Ethiopia. Journal of Agricultural Economics 21 (1999) 205-216. Elsevier Science Publishers.

Neupane, R. (2000). Tree-crop integration in agricultural land, their impact on soil fertility and farm income and influencing factors for adoption under the subsistence farming systems of the middle hills Nepal. Paper presented at the workshop on the Evolution and Sustainability of Intermediate Systems between extractivism and plantations, 28 June 28-1 July, 2000 in Lofoten, Norway.

Nicholson, C.F., Thornton, P.K., Mohammed, L., Muinga, R.W., Elbasha, E.H., Staal, S.J., & Thorpe, W. (1998). Smallholder Dairy Technology in Coastal Kenya: An Adoption and Impact Study. KARI, MOALDM, and ILRI.

Nkonya, E., Mwangi, W., Hugo, V., Anandajaayasekeram, P., & Moshi, A. (1998). Adoption of maize production technologies in northern Tanzania. Paper presented in the

sixth Eastern and Southern Africa Regional Maize Conference, 21-25th, September 1998 pp 371-374.

Ojiem, J.O., Ransom, J.K., Odongo, M., & Okwuoso, E.A. (1998). Agronomic and chemical characterization of potential green manure species in western Kenya. In Adoption of maize production technologies in northern Tanzania. Paper presented in the sixth Eastern and Southern Africa Regional Maize Conference, 21-25th, September, 1998 pp 210-217.

Oluoch-Kosura and Ackello-Ogutu. (1998). Role of Credit in the Uptake and Productivity of Improved Dairy Technologies in Kenya. In A.H. Freeman, M.A. Jabbar, & S.K. Ehui (Eds.), Role of Credit in the Uptake and Productivity of Improved Dairy Technologies in Sub-Saharan Africa. Socioeconomics and Policy Research Working Paper No. 22. The Livestock Policy Analysis Project, ILRI, Addis Ababa, Ethiopia.

Omiti, J. (2002). Smallholder dairy production and marketing-Opportunities and constraints. In D. Rangnekar & W.Thorpe (Eds.), Proceedings of a south-south workshop held at NDDP, Anand, India, 13-16 March 2001. The National Dairy Development Board, India, and ILRI, Nairobi, Kenya. 538pp.

Omore, A., Muriuki, H., Kenyanjui, M., Owango, M., & Staal, S.J. (1999). The Kenya Dairy sub-sector: A rapid appraisal. The MOA/KARI/ILRI.

Poate, C.D., & Daplyn, P.F. (1993). Data for Agrarian Development. Cambridge University Press.

Ritson, C. (1977). Agricultural Economics. Principles and Policy. Billing and Sons Limited, Worcester.

Rumell, R.J. (1976). Notes on Understanding correlation. Department of political science. University of Hawaii.

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

Salasya, B., Mwangi, W., & Verkuijl, H. (1998). An assessment of seed and fertilizer packages and the role of credit in smallholder maize production in western Kenya. In adoption of maize production technologies in northern Tanzania. Paper presented in the sixth Eastern and Southern Africa Regional Maize Conference, 21-25th, September, 1998 pp 371-374.

Scarpa, R., Kristjanson, P., Ruto, E., Radeny, M., Drucker, A., & Rege, J.E.O. (2003). Valuing Indigenous Animal Genetics Resources in Africa. A Comparison of Stated and Revealed Preference value Estimates. Journal of Ecological Economics 45 (2003) 409-426. Elsevier Science Publishers.

Shiferaw, B., & Holden, S.T. (1998). Resource degradation and adoption of land conservation technologies in the Ethiopian Highlands: A Case study in Andit Tid, North Shewa. Journal of Agricultural Economics 18, Issue 3 (1998) 233-247). Elsevier Science Publishers.

Staal, S.J., Chege, L., Kenyanjui, M., Kimari, A., Lukuyu, B., Njubi, D., Owango, M., Tanner, J., Thorpe, W., & Wambugu, M. (1997). Characterisation of Dairy Systems supplying the Nairobi milk market. A pilot survey in Kiambu District for the Identification of target groups and producers. May 1997. Revised May 1998

Staal, S.J., & Jabbar, M.A. (2000). Markets and livestock in the coming decades: Implications for Smallholder Highland Producers. International Centre for Integrated Mountain Development, Kathmadu (Nepal) System-Wide Livestock Programme, Addis Ababa (Ethiopia) FAO, Rome (Italy) CIP, Lima (Peru), p. 57-69.

Staal, S.J., Ehui, S., & Tanner, J. (2001). Livestock-Environment Interaction under Intensifying Production. In D.R. Lee & C.B. Barret (Eds.), Tradeoffs or Synergies? CAB International 2001.

Staal, S.J. (2002). The competitiveness of smallholder dairy production: Evidence from sub-saharan Africa, Asia and Latin America. In Rangnekar, D., & Thorpe, W. (Eds.), Smallholder Dairy production and marketing opportunities and constraints. Proceedings

of a south-south workshop held at National Dairy Development Board, Anand, India, 13-16 March 2001. NDDB, Anand, India, and ILRI, Nairobi. Kenya, 538pp.

Staal, S.J., Baltenweck, I., Waithaka, M.M., deWolff, T., & Njoroge, L. (2002). Location and uptake: integrated household and GIS analysis of technology adoption and land use, with application to smallholder dairy farms in Kenya. Journal of Agricultural Economics 27 (2002) 295-315, Elsevier Science Publishers.

Stata Corp. (2003). Stata statistical Software: Release 8.0. College Station, TX: Stata Corporation.

Steenkamp, J.B. (1987). Conjoint measurement in Ham quality Evaluation. Journal of Agricultural Economics (38) No. 3, 473-480.

Sy,H. A., Faminow ,M.D., Gary, V.J., and Gary, C. (1994). Estimating the Value of Cattle Characteristics Using an Ordered Probit Model. Paper presented at the 1993 CAEFMS Annual Meeting, Edmonton, July 11-14, 1993.

Tangka, F.K., Jabbar, M.A., and Shapiro, B.I. (2000). Gender roles and child nutrition in livestock production systems in developing countries: A critical review. Socio-economics and Policy Research Working Paper 27. ILRI (International Livestock Research Institute), Nairobi, Kenya. 64pp.

Tangka, F.K., Emerson, R.D., & Jabbar, M.A. (2002). Food security effects of intensified dairy farming: Evidence from the Ethiopian highlands. A critical review. Socio-economics and Policy Research Working paper 44. ILRI (International Livestock Research Institute), Nairobi, Kenya. 68pp

Tano, K., Kamuanga, M., Faminow, M.D., & Swallow, B. (2003). Using Conjoint Analysis To Estimate Farmers Preferences For Cattle Traits in West Africa. Journal of Ecological Economics 45 (2003) 393-407. Elsevier Science Publishers.

Timmer, C.P., Falcon W.P., and Pearson, S.R. (1983). Food Policy Analysis. Published for the World Bank. The John Hopkins University Press.

Varian, H.R. (1987). Intermediate Microeconomics. A Modern Approach. Fifth Edition W.W Norton and Company.

Waithaka, M., Wokabi A., Nyaganga, J., Ouma, E., de Wolf, T., Biwott, J., Staal, S.J., Ojowi, M., Ogidi, R., Njarro, I., & Mudavadi, P. (2002). Characterization of dairy systems in the western Kenya region. The Smallholder Dairy (R&D) Project.

Appendix 1

Table 1-A The Rotated Factor Loadings from PC analysis for all the Variables

Variable	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7	PC_8
dependency	0.09	0.07	0.05	-0.27	0.78*	0.22	0.02	0.02
transport	-0.14	-0.07	0.64*	0.05	0.01	-0.06	0.04	0.09
Anylabour	0.11	-0.03	0.68*	0.02	0.027	0.14	-0.01	-0.08
Inc	0.01	-0.07	0.69*	0.08	0.07	-0.18	-0.13	-0.06
SellMilk	0.13	0.03	0.33	-0.02	-0.05	-0.01	0.37	0.14
hhmemb	-0.1	-0.05	0.02	0.32	0.71*	-0.32	-0.017	-0.01
hhage	-0.01	-0.24	-0.12	0.77*	-0.1	0.08	0.02	-0.04
PPE	0.82*	0.19	-0.06	-0.02	-0.04	0.01	-0.04	0.08
Popn	0.47	-0.32	-0.07	-0.08	-0.12	-0.04	-0.05	0.53
popdensity	0.17	-0.11	-0.37	-0.28	0.29	-0.29	-0.14	0.21
TNUrdtype2km	-0.67*	0.18	-0.07	0.01	0.05	-0.08	0.09	-0.05
TNUrdtype1km	0.48	0.56	0.02	0.13	0.09	0.12	-0.07	-0.15
TNUrdtype3km	0.02	0.22	0.01	0.05	-0.08	-0.15	0.06	-0.69*
presentlandsize	-0.18	0.06	0.28	0.56	0.09	-0.04	0.06	-0.35
education	-0.04	0.12	0.51	-0.38	0.06	-0.42	-0.18	0.15
Dairy10	0.22	0.41	0.22	0.51	0.06	-0.16	0.17	0.19
fodder10ago	0.22	0.16	0.2	0.49	-0.01	-0.05	0.05	0.4
ownermanager	-0.31	-0.02	-0.11	0.11	-0.11	0.13	0.59	0.05
Exttopicsolstck	0.13	-0.14	0.19	0	0.07	-0.4	0.53	-0.09
Luhya	0.24	-0.87*	0.06	0.05	0.01	-0.04	-0.04	0.19
Luo	-0.81*	0.07	-0.01	-0.04	-0.09	0.03	-0.07	-0.02
Kisii	0.31	0.76*	-0.09	-0.15	-0.03	0.03	0.003	-0.002
fooddrank	0.03	-0.55	-0.3	-0.05	-0.12	0.05	-0.05	-0.26
offfarmYrank	-0.02	-0.17	0.18	-0.09	-0.04	-0.18	-0.67*	0.1
gender	-0.04	-0.07	0.04	0.01	-0.03	-0.79*	-0.07	-0.1

The variables with the asterisk (*) in each column are higly correlated

Appendix 1-B: Derivation of Marginal Probabilities.

Source: Greene, (2000), Stata Corp. 2003

The binomial probabilities are represented in terms of the cumulative distribution function (c.d.f) for the random variable e_i as follows:

$Pr(Y_i=1) = Pr(Y_i^*>0) = Pr(x_i^T\beta + e_i>0) = F(x_i^T)$

$Pr(Y_i=1) = Pr(Y_i^*>0) = 1-Pr(x_i^T\beta + e_i>0) = 1-F(x_i^T)$

Where $F(x_i^T\beta)$ is the c.d.f. for the standard normal variable.
Y_i^* is a continuous unobservable index
Y_i is the observed outcome.

x_i^T is a 1xK row vector of regressor values for observation i
β is a Kx1 column vector of regression coefficients.

The probit index function can be written as:

$$x_i^T\beta = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots \beta_k X_i$$

The probit coefficient estimates are the partial derivatives of the estimated probit index function with respect to the individual regressors:

$$\frac{\underline{x_i}^T\beta}{x_{ij}} = \beta_k$$

The marginal probability effects of the continuous explanatory variables are written as:

$$\frac{\underline{F(x_i^T)}}{x_{ij}} = f(x_i^T\beta)\,\beta_k$$

Thus the marginal probability effects assuming a normal distribution is the probit parameter estimate multiplied by a standardization factor.

The marginal probability effect of a dummy variable is computed by evaluating the the c.d.f at the two different values of the dummy variable, and then taking the difference:

$$F(x_{1i}^T) - F(x_{0i}^T\beta)$$

The marginal probability effects were changed to percentages

Table 1-C Principal Component Analysis for Variables used in Attribute Valuation

Variable	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6
Dairy 10 years ago	0.40	0.18	0.01	-0.63*	-0.28	0.07
Household income	0.05	-0.04	0.62	-0.19	-0.28	0.31
ppe	0.86*	0.05	0.04	0.09	-0.06	-0.03
Land size	-0.32	-0.01	0.22	-0.57*	-0.20	-0.16
gender	0.02	0.04	0.65*	0.07	0.17	-0.19
Luhya	0.42	-0.82*	0.02	0.29	-0.05	0.05
Luo	-0.89*	0.05	-0.06	0.10	-0.12	0.07
Nandi	-0.03	-0.02	-0.07	0.82*	0.22	-0.06
Kisii	0.27	0.89*	0.09	0.16	-0.01	-0.08
Education	0.11	0.11	0.77*	0.06	0.05	0.12
Cultural values	-0.29	-0.14	-0.16	-0.03	-0.06	0.49
Extension	-0.17	-0.29	0.21	-0.09	-0.61*	-0.35
dependency	-0.02	-0.11	0.23	-0.19	0.66*	-0.14
Importance of off-farm income	-0.07	-0.16	0.19	0.11	0.05	0.76*

Source: Author's Analysis

The variables with the asterisk (*) in each column are higly correlated

Table 1-D Heckman Test for the Equations on IDB and Income as Simultaneous Equations

Adoption of IDB	
	Robust Coefficients
gender	ns
gender•education	ns
presentlandsize	ns
Dairy10 (Did you have dairy breeds 10 years ago?) 1=Yes, 0=No	1.35(0.22) ***
TNUrdtype3km (The distance by earth road from the household to the nearest urban centre by earth road)	ns
exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise	ns
exttopicsolstck•education	ns
Ownermanager (Owner of the farm as well as manager? 1=Yes, 0=Otherwise)	ns
Education	ns
Kisii	ns
Popn (Population density in persons per km^2at 5 km radius)	ns
PPE	1.83(0.66) ***
dependency	-0.13(0.07) *
offfarmYrank	ns
fooddrank	ns
hhage	ns
constant	ns
Income	
offfarmYrank (Do you have off farm income?) 1=Yes, 0=No	0.40(0.09)***
fooddrank (The main expenditure in the household) 1=Food, 0=Otherwise	-0.49(0.09)***
education (Education in number of years)	0.11(0.01)***
presentlandsize (Total land size for the household in acres)	0.05(0.04)***
dependency (Ratio of dependants to adults in the household)	ns
Kisii (Ethnic background) 1=Kisii, 0=Luhya	-0.19(0.09)**
hhage (Age of the household head in years)	0.02(0.003)***
gender (Gender of the household head in years)	ns
constant	-2..35(0.27)***
No. of observations	1242
Wald (chi-square)	86.81

Source: Author's Analysis

*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level, and • means interactions.**

Values in brackets are standard errors

Wald test of independent equations (rho = 0): chi-square (1) = 0.10 Prob>chi-square=0.7530. The non-significance of the wald test shows that p=0 meaning that the two equations are independent

Table 1-E Heckman Test for the Equations on Napier and Income as Simultaneous Equations

Adoption of Napier	
	Robust coefficients
gender	ns
gender•education	ns
presentlandsize	ns
Dairy10 (Did you have dairy breeds 10 years ago?) 1=Yes, 0=No	1.35(0.22) ***
TNUrdtype3km (The distance by earth road from the household to the nearest urban centre by earth road)	ns
exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise	ns
exttopicsolstck•education	ns
Ownermanager (Owner of the farm as well as manager? 1=Yes, 0=Otherwise)	ns
Education	ns
Kisii	ns
Popn (Population density in persons per km^2at 5 km radius)	ns
PPE	1.83(0.66) ***
dependency	-0.13(0.07) *
offfarmYrank	ns
fooddrank	ns
hhage	ns
constant	ns
Income	
offfarmYrank (Do you have off farm income?) 1=Yes, 0=No	0.43(0.09)***
fooddrank (The main expenditure in the household) 1=Food, 0=Otherwise	-0.43(0.08)***
education (Education in number of years)	0.11(0.01)***
presentlandsize (Total land size for the household in acres)	0.05(0.02)***
dependency (Ratio of dependants to adults in the household)	ns
Kisii (Ethnic background) 1=Kisii, 0=Luhya	-0.19(0.09)**
hhage (Age of the household head in years)	0.02(0.003)***
gender (Gender of the household head in years)	ns
constant	-2..35(0.27)***
No. of observations	1242
Wald (chi-square)	86.81

Source: Author's Analysis

*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level, and • means interactions.**

Values in brackets are standard errors

Wald test of independent equations (rho = 0): chi-square (1) = 0.10 Prob > chi-square = 0.7530

Table 1-F Heckman Test for the Equations on the use of Anti-helminthics and Income as Simultaneous Equations

Use of anti-helminthics	
	Robust coefficients
gender	ns
gender● education	ns
presentlandsize	ns
Dairy10 (Did you have dairy breeds 10 years ago?) 1=Yes, 0=No	0.33(0.19) *
TNUrdtype3km (The distance by earth road from the household to the nearest urban centre by earth road)	ns
exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise	1.23(0.39)***
exttopicsolstck● education	ns
Ownermanager (Owner of the farm as well as manager? 1=Yes, 0=Otherwise)	ns
Education	ns
Kisii	0.62(0.28)**
Popn (Population density in persons per km^2at 5 km radius)	ns
PPE	ns
dependency	ns
offfarmYrank	ns
fooddrank	ns
hhage	ns
constant	ns
Income	
offfarmYrank (Do you have off farm income?) 1=Yes, 0=No	0.43(0.09)***
fooddrank (The main expenditure in the household) 1=Food, 0=Otherwise	-0.43(0.08)***
education (Education in number of years)	0.11(0.01)***
presentlandsize (Total land size for the household in acres)	0.05(0.02)***
dependency (Ratio of dependants to adults in the household)	ns
Kisii (Ethnic background) 1=Kisii, 0=Luhya	-0.19(0.09)**
hhage (Age of the household head in years)	0.02(0.003)***
gender (Gender of the household head in years)	ns
constant	-2..35(0.27)***
No. of observations	1242
Wald (chi-square)	86.81

Source: Author's Analysis

*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level, and ● means interactions.**

Values in brackets are standard errors

Wald test of independent equations(rho=0):chi-square(1)=0.00 Prob>chi-square=0.9661

Table 1-G Heckman Test for the Equations on the Adoption of IDB and Napier as Simultaneous Equations

Adoption of IDB	
	Robust coefficients
gender	ns
gender•education	ns
presentlandsize	ns
Dairy10 (Did you have dairy breeds 10 years ago?) 1=Yes, 0=No	1.08(0.17) **
TNUrdtype3km (The distance by earth road from the household to the nearest urban centre by earth road)	ns
exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise	0.48(0.24)**
exttopicsolstck•education	ns
Ownermanager (Owner of the farm as well as manager? 1=Yes, 0=Otherwise)	ns
Education	ns
Kisii	ns
Popn (Population density in persons per km^2at 5 km radius)	ns
PPE	ns
dependency	-0.1(0.05) *
offfarmYrank	ns
fooddrank	ns
hhage	ns
constant	ns
Napier	
gender	0.58(0.18)***
gender•education	0.04(0.01***
presentlandsize	ns
fodder10 (Did you have fodder 10 years ago?) 1=Yes, 0=No	0.39(0.14) ***
TNUrdtype3km (The distance by earth road from the household to the nearest urban centre by earth road)	ns
exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise	ns
exttopicsolstck•education	ns
Ownermanager (Owner of the farm as well as manager? 1=Yes, 0=Otherwise)	ns
Education	ns
Kisii	1.01(0.18)***
Popn (Population density in persons per km^2at 5 km radius)	0.001(0.0002)***
PPE	ns
dependency	ns
offfarmYrank	ns
fooddrank	ns
hhage	0..09(0.005)*
constant	-3.57(0.59)***
No. of observations	921
Wald (chi-square)	118.68

Source: Author's Analysis

*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level, and • means interactions.**

Values in brackets are standard errors

Wald test of independent equations (rho = 0): chi-square(1) = 0.17 Prob > chi-square = 0.6829

Table 1-H Heckman Test for the Equations on Adoption of IDB and Anti-helminthnics as Simultaneous Equations

Adoption of IDB	
	Robust Coefficients
gender	ns
gender●education	ns
presentlandsize	-0.025(0.012)**
Dairy10 (Did you have dairy breeds 10 years ago?) 1=Yes, 0=No	0.95(0.14)***
TNUrdtype3km (The distance by earth road from the household to the nearest urban centre by earth road)	ns
exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise	ns
exttopicsolstck●education	ns
Ownermanager (Owner of the farm as well as manager? 1=Yes, 0=Otherwise)	ns
Education	-0.044(0,025)*
Kisii	ns
Popn (Population density in persons per km^2at 5 km radius)	ns
PPE	1.06(0.38)***
dependency	ns
offfarmYrank	ns
fooddrank	0.18(0.01)*
hhage	ns
constant	ns
Use of antihelminthnics	
Income	0.38(0.11)***
gender	ns
gender●education	ns
presentlandsize	ns
Dairy10 (Did you have dairy breeds 10 years ago?) 1=Yes, 0=No	0.49(0.11) ***
TNUrdtype3km (The distance by earth road from the household to the nearest urban centre by earth road)	ns
exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise	0.59(0.19)***
exttopicsolstck*education	ns
Ownermanager (Owner of the farm as well as manager? 1=Yes, 0=Otherwise)	ns
Education	ns
Kisii	0.50(0.11)***
Popn (Population density in persons per km^2at 5 km radius)	ns
PPE	ns
dependency	ns
offfarmYrank	ns
fooddrank	-0.31(0.092)***
hhage	-0.01(0.004)*
constant	ns
No. of observations	921
Wald (chi-square)	87.11

Source: Author's Analysis

*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level, and ● means interactions.**

Values in brackets are standard errors

Wald test of independent equations. (rho = 0): chi-square(1) = 0.39 Prob > chi-square = 0.5299

Table 1-I Heckman Test for the Equations on the Adoption of Napier and Anti-helminthics as Simultaneous Equations

Napier	
	Robust Coefficients
gender	ns
gender● education	ns
presentlandsize	ns
Fodder10ago (Did you have fodder10 years ago?) 1=Yes, 0=No	0.39(0.17) *
TNUrdtype3km (The distance by earth road from the household to the nearest urban centre by earth road)	ns
exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise	ns
exttopicsolstck● education	ns
Ownermanager (Owner of the farm as well as manager? 1=Yes, 0=Otherwise)	ns
Education	ns
Kisii	0.93(0.22)***
Popn (Population density in persons per km^2at 5 km radius)	0.002(0.0005)***
PPE	2.57(0.60)***
dependency	-0.13(0.07) *
offfarmYrank	ns
fooddrank	ns
hhage	ns
constant	-2.98(0.75)***
Use of anti-helminthnics	
Income	0.42(0.11)***
gender	ns
gender● education	ns
presentlandsize	ns
Dairy10 (Did you have dairy breeds 10 years ago?) 1=Yes, 0=No	0.49(0.11) ***
TNUrdtype3km (The distance by earth road from the household to the nearest urban centre by earth road)	ns
exttopicsolstck (received extension services on dairy production?) 1=received, 0=Otherwise	0.58(0.19)***
exttopicsolstck●education	ns
Ownermanager (Owner of the farm as well as manager? 1=Yes, 0=Otherwise)	ns
Education	ns
Kisii	0.50(0.11)***
Popn (Population density in persons per km^2at 5 km radius)	ns
PPE	ns
dependency	ns
offfarmYrank	ns
fooddrank	-0.36(.0.098)***
hhage	-0.01(0.004)*
constant	ns
Number of observations	921
Wald (chi-square)	87.11

Source: Author's Analysis

*** means significant at 10 % level, ** means significant at 5% level, *** means significant at 1% level, and ● means interactions.**

Values in brackets are standard errors

Wald test of independent equations. (rho = 0): chi-square(1) = 0.17 Prob > chi-square = 0.68

Table 1-J Classification for Adopters and Non-adopters

		Predicted		Total
		Adopters	Non-adopters	
Improved dairy breed	**Observed**			
	Adopters	402	104	506
	Non-adopters	127	288	415
Total		529	392	921
Positive prediction		79%		
Negative prediction			69%	
Correct classification				75%
Napier	**Observed**			
	Adopters	640	88	727
	Non-adopters	45	148	193
Total		685	236	921
Positive prediction		88%		
Negative prediction			77%	
Correct classification				85%
Use of Antihelminthics	**Observed**			
	Adopters	486	167	653
	Non-adopters	93	175	268
Total		519	32	921
Positive prediction		74%		
Negative prediction			65%	
Correct classification				71%

Source: Author's Analysis

Appendix 1-N: An illustration of calculating the mapped predicted probabilities.

1. generate a constant by adding all the coefficients of the variables in the estimated equation. For the IDB equation, excluding the coefficient of the significant spatial factor. All the coefficients were divided by 0.625 to change them to logit variables for easier use of the logit model to predict probability. All the coefficients were then multiplied by mean of the variables.An illustration is done using the IDB equation

   xi:probit impdairy Inc i.Exttopicsonlstock*education i.gender*education presentlandsize Dairy10 TNUrdtype3km Kisii PPE Popn ownermanager hhage dependency offfarmYrank fooddrank, robust nolog

   gen CONSTANT=coef[cons]/0.625 +(coef[Inc]/0.625)*0.28 +(coef[IExttopics1]/0.625)*0.34 +(coef[IExtXeduca1]/0.625)*2.7 +(coef[IgenXeduca1]/0.625)*6.82 +(coef[Igender1]/0.625)*0.83 +(coef[presentlandsize]/0.625)*3.22+(coef[Kisii]/0.625)*0.322 +(coef[hhage]/0.625)*48.36 +(coef[dependency]/0.625)*1.61+ (coef[Dairy10]/0.625)*0.27+(coef[TNUrdtype3km]/0.625)*2.41 +(coef[Popn]/0.625)*625 + (coef[ownermanager]/0.625)*0.58+ (coef[offfarmYrank]/0.625)*0.50+ (coef[fooddrank]/0.625)*0.58

2. generate an index: Multiply the coefficient of the significant spatial factor by the variable itself, then add the product to the constant obtained in 1

   gen INDEX= CONSTANT+(coef[PPE]/0.625)*PPE

3. get the predicted probability of the index using the logit model

   gen pIMPIndex=exp(IMPIndex)/(1+exp(conIMPIndex))

3. A similar method was done to get the predicted probability for Napier. There was no predicted probability for the use of antihelminthics because the regression did not show any spatial factor that was significant.

Appendix 11-A

SMALLHOLDER DAIRY PROJECT (R & D)
Ministry of Agriculture
Kenya Agricultural Research Institute
International Livestock Research Institute

Western Kenya Characterisation Survey
April – July, 2000

Survey Questionnaire

DISTRICT	DIVISION		SUBLOCATIONS					
	Code		Code		Code		Code	
BUNGOMA	11	KIMILILI	3720 3718	Kamukuywa Kimilili Township	3716	Kibingei	3717	Kimilili
	12	NALONDO	3695	North Nalondo	3693	South Nalondo	3694	West Nalondo
KAKAMEGA	21	IKOLOMANI	3470 3478	Shikulu Shisejeri	3472 3474	Shivagala Musoli	3473	Shibuname
	22	MALAVA/ KABRAS	3476	Shitoli	3353	Samitsi	3359	Surungai
KISII	31	MASABA	691 685	Ichuni Metembe	696 693	Kiamokama Buguche	686 695	Matibo Mogweke
	32	SUNEKA	746 743	Bomariba Bomokora	745 744	Bogitaa Nyamwari	741 749	Bomorenda Bogiakumu
NANDI	41	KAPSABET	3755 3754	Kaptildil Chepkongony	3761	Kapchorwa	3764	Cheboite
	42	KILIBWONI	3791 3798	Arwos Lelwak	3806	Ndubeneti	3802	Songoliet
NYAMIRA	51	EKERENYO	784 783	Bonyarwande Bomwagamo	789	Boikeira	792 787	Magwagwa Bonyegwe
	52	RIGOMA	763 806	Mwabundusi Bocharia	765 805	Mwagechure Embaro	764 803	Girango Nyamakoroto
RACHUONYO	61	KENDU BAY	124 116	Komulo Njira Kanyapir	199 128	Kamser Seka Kogweno Kawour	201 322	Kajiel Kobila
	62	OYUGIS	215 185	Kakangutu West Kachieng	187 213	Kawere Kamagak Kokwanyo East	325 170	North Kachien Kodera Kamiyawa
VIHIGA	71	TIRIKI WEST	3504 3488	Kapsotik Gimarakwa	3493	Gavundunyi	3491	Giamamoi
	72	VIHIGA	3439 3427	Mbihi Chagenda	3442	Magui	3431	Mahanga

A/1 HH HEAD DETAILS

ETHNIC AFFILIATION

1 = Kikuyu
2 = Luhya (specify sub-group_____)
3 = Luo
4 = Kisii
5 = Kalenjin (specify sub-group_____)
6 = Kamba
7 = Mijikenda
8 = Asian
9 = European
10 = Other Gikuyu (Embu Meru)
11 = Maasai
12 = Suba
13 = Teso
14 = Other (specify)_____

EDUCATION LEVEL

0 = No formal education
1 = Standard 1 through 4
2 = Standard 5 through 8
3 = Form 1 or 2
4 = Form 3 or 4
5 = Post secondary school ('A' level)
6 = Technical college (diploma or certificate)
7 = Adult literacy education
8 = University
9 = Other (specify)_____

RELIGION

1 = Catholic
2 = Protestant (all except for SDA)
3 = SDA
4 = Muslim
5 = Hindu
6 = Traditional African faith
7 = Other(specify)_____

ENUMERATOR NAME _____ ENUMERATOR CODE _____
DATE of interview (DD/MM /YY) /___/___/2000
DISTRICT [___]
DIVISION [___]
SUB-LOCATION [___ ___ ___ ___]

FAMILY NAME _____

RESPONDENT'S NAME _____

RESPONDENT's POSITION IN THE HOUSEHOLD [_][_]

1 = Husband	5 = Daughter
2 = Wife	6 = House help/ farm labourer
3 = Co-wife	7 = Hired manager
4 = Son	8 = Other (specify)_____

TYPE OF HOMESTEAD:
Monogamous (married) [ ]
Polygamous (married) [ ] (tick)
Single household head (unmarried) [ ]

IF THIS IS A POLYGAMOUS HOMESTEAD:
How many co-wives? [ ] (number)
How many co-wives resident? [ ] (number)

What part of the polygamous homestead is being interviewed?
Entire homestead (husband and all co-wives) [ ] (tick)
Only the "household" (property and activities) of one co-wife, who is co-wife number..
[ ] (number)

SECTION A. HOUSEHOLD COMPOSITION/ LABOUR AVAILABILITY AND USE (ALL HOUSEHOLDS)

A/1. Provide the following details about the household head (see codes on opposite page);

Sex 1 = Male 2 = Female	Age (years)	Years of farming experience (years)	Ethnic affiliation (code)	Highest education level completed (code)	Religion (code)
[___]	[___]	[___]	[___]	[___]	[___]

A/2. Who is the farm owner ? [__]
Who is the farm manager ? [__]

1 = Husband	5 = Daughter
2 = Wife	6 = House help/ farm labourer
3 = Co-wife	7 = Hired manager
4 = Son	8 = Other (specify)_____

A/3. Give details of all household members (including the HH head) living permanently on the compound and their primary activities and/or occupations (on and off farm):

BE SURE THAT ALL CHILDREN AND INFANTS ARE INCLUDED

Name (first name only)	Age (yrs)	Sex 1= M 2 = F	Primary Activities AND/OR Occupations	Name (first name only)	Age (yrs)	Sex 1= M 2 = F	Primary Activities AND/OR Occupations
1		[___]	[___] [___]	15		[___]	[___] [___]
2		[___]	[___] [___]	16		[___]	[___] [___]
3		[___]	[___] [___]	17		[___]	[___] [___]
4		[___]	[___] [___]	18		[___]	[___] [___]
5		[___]	[___] [___]	19		[___]	[___] [___]
6		[___]	[___] [___]	20		[___]	[___] [___]
7		[___]	[___] [___]	21		[___]	[___] [___]
8		[___]	[___] [___]	22		[___]	[___] [___]
9		[___]	[___] [___]	23		[___]	[___] [___]
10		[___]	[___] [___]	24		[___]	[___] [___]
11		[___]	[___] [___]	25		[___]	[___] [___]
12		[___]	[___] [___]	26		[___]	[___] [___]
13		[___]	[___] [___]	27		[___]	[___] [___]
14		[___]	[___] [___]	28		[___]	[___] [___]

* A person is in residence if they sleep in the house a majority of nights per week.

Activities and occupations
0 = None
1 = Farm management/farmer
2 = Civil servant
3 = Employee in private enterprise
4 = Businessman
5 = Labourer on farm
6 = Labourer off farm
7 = Retired with pension
8 = Retired without pension
9 = Religious leader
10 = In school/college
11 = Pre-school age
12 = Other(specify)_____

IS THE HOUSEHOLD ENGAGED IN ANY AGRICULTURAL OR LIVESTOCK PRODUCTION?

[___] = YES

[___] = NO

IF NO, SKIP EVERYTHING ELSE AND GO TO SECTION G (ON PAGE 183)

SECTION B - FARM ACTIVITIES AND FACILITIES

B/1.Indicate who in the household is primarily responsible for carrying out the following tasks.

CATTLE ACTIVITIES	Main people doing the work are: (see codes below)
Grazing animals	[__][__]
Cut and carry of feed	[__][__]
Feeding	[__][__]
Planting, weeding and manuring forage	[__][__]
Milking	[__][__]
Marketing milk	[__][__]
Spraying/Dipping	[__][__]
Cleaning animal shed or boma	[__][__]
Obtaining AI/ Veterinary Services	[__][__]
Fetching water for animals or watering animals	[__][__]
OTHER ACTIVITIES	
Activities related to other livestock	[__][__]
Preparing Fields for food crops	[__][__]
Planting food crops	[__][__]
Weeding food crops	[__][__]
Harvesting food crops	[__][__]
Planting cash crops	[__][__]
Weeding cash crops	[__][__]
Harvesting cash crops	[__][__]

PRIMARY RESPONSIBILITIES FOR CARRYING OUT TASKS

1 = Household head
2 = Adult Males (other than HH head)
3 = Adult Females (other than HH head)
4 = Any Adult in Household
5 = Any Household member
6 = Children
7 = Long-term laborers
8 = Casual laborers
9 =Other (specify)___

B/2 Does the household or farm have: (tick)

Electricity supply	[___]=YES	[___]=NO
A telephone connection	[___]=YES	[___]=NO
Piped public water supply	[___]=YES	[___]=NO

B/3 Which of the following means of transportation does the household or farm have? [___]=NONE (tick)
List: Item 1 [___] Item 2 [___] Item 3 [___] Item 4 [___]

1 = Bicycle
2 = Wheelbarrow
3 = Handcart
4 = Animal drawn cart
5 = Motorcycle
6 = Tractor
7 = Pick-up
8 = Car
9 = Other specify_____

B/4 How far is the household from (in kilometers);

A road open to vehicles all year	[___ ___ . ___] Km
A road passable only during the dry season	[___ ___ . ___] Km
The closest market or trading centre	[___ ___ . ___] Km

B/5 Do you currently employ any long-term labourers? [___] = YES [___]= NO

If Yes, list all those you have employed in the last 12 months: their first name, sex, their main activities on the farm, the percentage of time spent on cattle activities and their wages.

Long term labourers								
		Main activities (see activities codes below)					Are lodging and meals also provided? 1=YES, 2=NO	
		Activity 1	Activity 2	Activity 3			Lodging	Meals
[___]	[___]	[___]	[___]	[___]	[___%]	[_____]	[___]	[___]
[___]	[___]	[___]	[___]	[___]	[___%]	[_____]	[___]	[___]
[___]	[___]	[___]	[___]	[___]	[___%]	[_____]	[___]	[___]
[___]	[___]	[___]	[___]	[___]	[___%]	[_____]	[___]	[___]
[___]	[___]	[___]	[___]	[___]	[___%]	[_____]	[___]	[___]

B/6 In the last 12 months, have you employed any casual labourers? [___] = YES [___]= NO

If YES: What activities did they carry out? (List) [___] [___] [___] [___] [___]

How much are they paid? Kshs [___] per [___]=half day (8 to1)

OR per [___]= day (8 to 6)

Did payment include lunch? [___] = YES [___]= NO

Activities codes (B/5 and B/6)

1 = Grazing animals
2 = Cut and carry of feed
3 = Feeding
4 = Planting, weeding and manuring forage
5 = Milking
6 = Marketing milk
7 = Spraying/Dipping
8 = Cleaning animal shed or boma
9 = Obtaining AI/ Veterinary Services
10 = Fetching water for animals or watering animals
11 = Activities related to other livestock
12 = Preparing Fields for food crops
13 = Planting food crops
14 = Weeding food crops
15 = Harvesting food crops
16 = Planting cash crops
17 = Weeding cash crops
18 = Harvesting cash crops
19 = All activities related to cattle only
20 = All activities related to cattle and other animals
21 = All activities related to crops
22 = Other (specify)_____

LAND TENURE/ LAND USE

B/7 What year did you establish your farm? [_ _ _ _]

What was the land size when you established your farm ? [_ _ . _] (acres)

B/8 Of the land you own now

What is the total size now in acres? [___ ___.___] (acres)

How many plots is it divided into? [___ ___]

Note: the definition of a plot is a single piece of land which is connected. Pieces of land not connected are considered separate plots.

Of the land you farm or graze but do not own

How much land do rent from others in acres? [___ ___.___] (acres)

How much communal/public land do you use in acres? [___ ___.___] (acres)

B/9 What are your main objectives in farming?
(List first 4 in order of importance, 1= most important, 2= next important, etc)

Objective	Rank
Food supply	
Basic income / profit	
Conservation of soils and soil fertility	
Livestock feed supply	
Household energy	
Social prestige and status	
Other (specify)_____	

B/10 What is the main source of food for your household? [___] (code)
1= own farm production
2= purchased
3=from other family members
4=other (specify)_____

B/11 Do you store or preserve food for use in another season? [___]=YES [___]=NO (tick)

B/12 Which soil conservation measures do you undertake on your farm? [___][___] (code)
1=terracing
2=strip cropping
3=trash lines
4=other (specify)_____

B/13 What are your sources of energy and/or fuel wood? [___][___] (code)
1= own fuel wood
2= bought fuel wood or charcoal
3= biogas
4= solar power
5= public electricity supply
6 =other (specify)_____

B/14 How many times a year do you normally plant:
Maize [___] (number of plantings)
Finger millet [___] (number of plantings)
Sorghum/Millet [___] (number of plantings)

B/15 Codes for use in PLOT TABLE

NON-AGRICULTURAL USE OF LAND
Note: paddocks are considered pasture

00 = all non-agricultural use of land, including homestead, stores, etc.

FOOD CROPS
1= arrow root
2= bananas
3= beans
4= cabbage,cauliflower
5= carrots
6 = cassava
7 = cow peas
8 = cucumber
9 = finger millet
10= French beans
11 = green pepper
12= Irish potatoes
13= kale (sukuma)
14= maize
15 = onions
16 = pawpaw
17 = pigeon peas
18= sorghum / millet
19 = soya beans
20= sweet potatoes
21= tomatoes
22 = other vegetables for market

CASH CROPS
23 = barley
24 = coffee
25 = cotton
26 = cut flowers
27 =fruit/tree crops
28 = groundnuts
29= pyrethrum
30 = rice
31 = rye
32 = simsim
33 = sugarcane (Juice)
34 = sugarcane (Sugar)
35 = sunflower
36 = tea
37 = wheat

PASTURE and FORAGES
38= desmodium
39= fallow and natural pasture
40 = fodder beet
41 = fodder trees
42= lucerne
43= napier grass
44= oats
45 = planted pasture
46 = thatch grass
47 = vetch

48= other crop or forage (specify) _____

LAND TENURE
1 = Traditional
2 = Freehold (has certificate/title deed)
3 = Leasehold
4 = Rented from another individual
5 = Share cropping
6= Informal and not raying rent (e.g roadside)
7 = Other (specify) _____

B/15 PLOT TABLES For every plot a)owned by the household
b) rented from others
c) rented to others
d) and informally held (such as roadsides)
fill in one row for each patch or cropping mix within each plot (see codes on opposite page)

Note: the definition of a plot is a single piece of land which is connected. Pieces of land not connected are considered separate plots. Make sure that the sum of the proportions equals 1. The first crop indicated has to be the major crop on that land, in term of density.

Plot 1	Plot size (acres) [___.___]	Land tenure [__] Rented from another? [__]1=yes 2=no	If rented, rent paid per year for plot [_____]	Distance from homestead (kms) [_____]	
	Crops present	Proportion of plot 1 allocated to this patch	Is Napier planted on contours ? 1=yes 2=no	Use manure ? 1=yes 2=no	Chemical fertilizer ? 1=yes 2=no
Patch/cropping mix 1	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 2	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 3	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 4	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 5	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Plot 2	Plot size (acres) [___.___]	Land tenure [__] Rented from another? [__]1=yes 2=no	If rented, rent paid per year [_____]	Distance from homestead (kms) [_____]	
	Crops present	Proportion of plot 2 allocated to this patch	Is Napier planted on contours ? 1=yes 2=no	Use manure ? 1=yes 2=no	Chemical fertilizer ? 1=yes 2=no
Patch/cropping mix 1	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 2	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 3	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 4	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 5	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Plot 3	Plot size (acres) [___.___]	Land tenure [__] Rented from another? [__]1=yes 2=no	If rented, rent paid per year [_____]	Distance from homestead (kms) [_____]	
	Crops present	Proportion of plot 3 allocated to this patch	Is Napier planted on contours ? 1=yes 2=no	Use manure ? 1=yes 2=no	Chemical fertilizer ? 1=yes 2=no
Patch/cropping mix 1	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 2	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 3	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 4	[_][_][_][_][_]	___/___	[__]	[__]	[__]
Patch/cropping mix 5	[_][_][_][_][_]	___/___	[__]	[__]	[__]

B/15 Codes for use in PLOT TABLE

NON-AGRICULTURAL USE OF LAND
Note: paddocks are considered pasture

00 = all non-agricultural use of land, including homestead, stores, etc.

FOOD CROPS
1= arrow root
2= bananas
3= beans
4= cabbage,cauliflower
5= carrots
6 = cassava
7 = cow peas
8 = cucumber
9 = finger millet
10= French beans
11 = green pepper
12= Irish potatoes
13= kale (sukuma)
14= maize
15 = onions
16 = pawpaw
17 = pigeon peas
18= sorghum / millet
19 = soya beans
20= sweet potatoes
21= tomatoes
22 = other vegetables for market

CASH CROPS
23 = barley
24 = coffee
25 = cotton
26 = cut flowers
27 =fruit/tree crops
28 = groundnuts
29= pyrethrum
30 = rice
31 = rye
32 = simsim
33 = sugarcane (Juice)
34 = sugarcane (Sugar)
35 = sunflower
36 = tea
37 = wheat

PASTURE and FORAGES
38= desmodium
39= fallow and natural pasture
40 = fodder beet
41 = fodder trees
42= lucerne
43= napier grass
44= oats
45 = planted pasture
46 = thatch grass
47 = vetch

48= other crop or forage (specify) _____

LAND TENURE
1 = Traditional
2 = Freehold (has certificate/title deed)
3 = Leasehold
4 = Rented from another individual
5 = Share cropping
6= Informal and not raying rent (eg roadside)
7 = Other (specify) _____

B/15 PLOT TABLES (continued)

	Plot size (acres) [___.__]	Land tenure [__] Rented from another? [_]1=yes 2=no	If rented, rent paid per year for plot [_____]	Distance from homestead (kms) [____]	
	Crops present	Proportion of plot 1 allocated to this patch	Is Napier planted on contours ? 1=yes 2=no	Use manure ? 1=yes 2=no	Chemical fertilizer ? 1=yes 2=no
cropping mix 1	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 2	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 3	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 4	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 5	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
	Plot size (acres) [___.__]	Land tenure [__] Rented from another? [_]1=yes 2=no	If rented, rent paid per year [_____]	Distance from homestead (kms) [____]	
	Crops present	Proportion of plot 2 allocated to this patch	Is Napier planted on contours ? 1=yes 2=no	Use manure ? 1=yes 2=no	Chemical fertilizer ? 1=yes 2=no
cropping mix 1	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 2	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 3	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 4	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 5	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
	Plot size (acres) [___.__]	Land tenure [__] Rented from another? [_]1=yes 2=no	If rented, rent paid per year [_____]	Distance from homestead (kms) [____]	
	Crops present	Proportion of plot 3 allocated to this patch	Is Napier planted on contours ? 1=yes 2=no	Use manure ? 1=yes 2=no	Chemical fertilizer ? 1=yes 2=no
cropping mix 1	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 2	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 3	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 4	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]
cropping mix 5	[_][_][_][_][_][_]	___/___	[__]	[__]	[__]

B/15 Codes for use in PLOT TABLE

NON-AGRICULTURAL USE OF LAND
Note: paddocks are considered pasture

00 = all non-agricultural use of land, including homestead, stores, etc.

FOOD CROPS
1= arrow root
2= bananas
3= beans
4= cabbage,cauliflower
5= carrots
6 = cassava
7 = cow peas
8 = cucumber
9 = finger millet
10= French beans
11 = green pepper
12= Irish potatoes
13= kale (sukuma)
14= maize
15 = onions
16 = pawpaw
17 = pigeon peas
18= sorghum / millet
19 = soya beans
20= sweet potatoes
21= tomatoes
22 = other vegetables for market

CASH CROPS
23 = barley
24 = coffee
25 = cotton
26 = cut flowers
27 =fruit/tree crops
28 = groundnuts
29= pyrethrum
30 = rice
31 = rye
32 = simsim
33 = sugarcane (Juice)
34 = sugarcane (Sugar)
35 = sunflower
36 = tea
37 = wheat

PASTURE and FORAGES
38= desmodium
39= fallow and natural pasture
40 = fodder beet
41 = fodder trees
42= lucerne
43= napier grass
44= oats
45 = planted pasture
46 = thatch grass
47 = vetch

48= other crop or forage (specify) _____

LAND TENURE
1 = Traditional
2 = Freehold (has certificate/title deed)
3 = Leasehold
4 = Rented from another individual
5 = Share cropping
6= Informal and not raying rent (eg roadside)
7 = Other (specify) _____

B/15 PLOT TABLES (continued)

Plot 7	Plot size (acres) [____.____]	Land tenure [___] Rented from another? [__]1=yes 2=no	If rented, rent paid per year for plot [_____]	Distance from homestead (kms) [_____]	
	Crops present	Proportion of plot 1 allocated to this patch	Is Napier planted on contours ? 1=yes 2=no	Use manure ? 1=yes 2=no	Chemical fertilizer ? 1=yes 2=no
Patch/cropping mix 1	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 2	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 3	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 4	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 5	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Plot 8	Plot size (acres) [____.____]	Land tenure [___] Rented from another? [__]1=yes 2=no	If rented, rent paid per year [_____]	Distance from homestead (kms) [_____]	
	Crops present	Proportion of plot 2 allocated to this patch	Is Napier planted on contours ? 1=yes 2=no	Use manure ? 1=yes 2=no	Chemical fertilizer ? 1=yes 2=no
Patch/cropping mix 1	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 2	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 3	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 4	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 5	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Plot 9	Plot size (acres) [____.____]	Land tenure [___] Rented from another? [__]1=yes 2=no	If rented, rent paid per year [_____]	Distance from homestead (kms) [_____]	
	Crops present	Proportion of plot 3 allocated to this patch	Is Napier planted on contours ? 1=yes 2=no	Use manure ? 1=yes 2=no	Chemical fertilizer ? 1=yes 2=no
Patch/cropping mix 1	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 2	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 3	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 4	[__][__][__][__][__]	____/____	[___]	[___]	[___]
Patch/cropping mix 5	[__][__][__][__][__]	____/____	[___]	[___]	[___]

B/16 If the farm was established then, which crops do you grow now which you did not grow 10 years ago?

[__][__][__][__][__]

(Use codes for PLOT TABLES F/15 on previous pages)

B/17 Which crops did you grow 10 years ago which you do not grow now?

[__][__][__][__][__]

(Use codes for PLOT TABLES F/15 on previous pages)

Land preparation and animal traction:

B/18 Indicate the number of acres of land prepared using different methods in the most recent seasons:

	Acres in cropping season 1	Acres in cropping season 2
By hand hoe/jembe		
Using animal draft power		
By tractor		
Other (specify)		

B/19 Indicate, of the animals you own , how many of each type are used regularly for the following tasks:

	Animal type (indicate number of each)				
Animal tasks	Oxen	Bulls	Cows	Donkeys	Other (specify)
Land preparation					
Planting/furrowing					
Weeding					
Transport/hauling cart					
Other (specify)					

Have you ever used crossbred or pure dairy cattle for land preparation or transport?

[___]=YES [___]=NO

B/20 If you have used animals belonging to others for draft power in the last 12 months, fill the following table for each animal type:

		If rented what was the cost		
Animal type	Animal task(s)	Unit of hire	Cost per unit (Kshs)	Goods given in exchange
[___]	[___] [___]	[___]		[___] [___]
[___]	[___] [___]	[___]		[___] [___]
[___]	[___] [___]	[___]		[___] [___]
[___]	[___] [___]	[___]		[___] [___]

Animal Type
1 = Ox
2 = Cow
3 = Bull
4 = Donkey
5 = Other (specify) _____

Animal Tasks
1 = Land preparation
2 = Planting/furrowing
3 = Weeding
4 = Transport
5 = Other (specify) _____

Unit of Hire
1 = Acre
2 = Per day
3 = Per kilometer
4 = Per task
5 = Other (specify) _____

Goods Given in Exchange
0 = None
1 = Milk
2 = Fodder
3 = Manure
4 = Labour
5 = Food or food crops
6 = Other (specify) _____

B/21 Do you use manure or cattle slurry? [___]=YES [___]=NO (tick)

If yes, to what crops is manure/slurry applied? (codes below) 1st [___] 2nd [___] 3rd [___]

Others [___][___][___][___][___]

FOOD CROPS	CASH CROPS	PASTURE and FORAGES
1= arrow root	23 = barley	38= desmodium
2= bananas	24 = coffee	39= fallow and natural pasture
3= beans	25 = cotton	40 = fodder beet
4= cabbage,cauliflower	26 = cut flowers	41 = fodder trees
5= carrots	27 =fruit/tree crops	42= lucerne
6 = cassava	28 = groundnuts	43= napier grass
7 = cow peas	29= pyrethrum	44= oats
8 = cucumber	30 = rice	45 = planted pasture
9 = finger millet	31 = rye	46 = thatch grass
10= French beans	32 = simsim	47 = vetch
11 = green pepper	33 = sugarcane (Juice)	
12= Irish potatoes	34 = sugarcane (Sugar)	
13= kale (sukuma)	35 = sunflower	48= other crop or forage (specify) _____
14= maize	36 = tea	
15 = onions	37 = wheat	
16 = pawpaw		
17 = pigeon peas		
18= sorghum / millet		
19 = soya beans		
20= sweet potatoes		
21= tomatoes		
22 = other vegetables for market		

B/22 If you use own-farm manure/slurry, from which animals does it come? (list) [___][___][___]

1 = Zebu cattle	4 = Poultry
2 = Dairy cattle	5 = Pigs
3 = Small ruminants	6 = Other (specify)_____

B/23 Do you purchase manure? [___]=YES [___]=NO (tick)

If Yes, how much did you buy during the last 12 months? Purchase Unit [__] (codes)

Price per unit [___] (Kshs)

No. of units purchased [ ]

Where did the manure come from? [___] (codes

MANURE PURCHASE UNITS	WHERE DOES THE MANURE COME FROM?
1 = Kg	1 = Within the sub location
2 = Standard sack	2 = Within the district
3 = Wheelbarrow	3 = Outside the district
4 = Donkey cart load	
5 = Pick-up load	
6 = Lorry load	
7 = Other (specify)_____	

B/24 Do you purchase fertiliser? [___]=YES [___]=NO (tick)

If Yes, indicate the total cost for the last 12 months [___ ___ ___ ___] (Kshs)

If yes, to what crops is fertiliser applied? (codes above) 1st [___] 2nd [___] 3rd [___]

Others [___][___][___][___][___]

B/25 If you sell fodder or feed, how much did you sell in the last 12 months and what was the unit price? (If quantity/unit is uncertain record total income).

Feed types	Unit (code)	Total quantity sold in last 12 months (number of units)	Price per unit (Kshs)	Total income from sale
Napier grass	[ ]	[ ]	[ ]	[ ]
Maize stover green	[ ]	[ ]	[ ]	[ ]
Maize stover dry	[ ]	[ ]	[ ]	[ ]
Roadside grass	[ ]	[ ]	[ ]	[ ]
Other crop residues	[ ]	[ ]	[ ]	[ ]
Forage legumes	[ ]	[ ]	[ ]	[ ]
Straw/Hay	[ ]	[ ]	[ ]	[ ]
Dairy meal	[ ]	[ ]	[ ]	[ ]
Maize bran	[ ]	[ ]	[ ]	[ ]
Maize germ	[ ]	[ ]	[ ]	[ ]
Wheat bran	[ ]	[ ]	[ ]	[ ]
Pollard	[ ]	[ ]	[ ]	[ ]
Oilseed byproducts	[ ]	[ ]	[ ]	[ ]
Poultry waste	[ ]	[ ]	[ ]	[ ]
Pyrethrum marc	[ ]	[ ]	[ ]	[ ]
Brewer's waste	[ ]	[ ]	[ ]	[ ]
Minerals/salt	[ ]	[ ]	[ ]	[ ]

Units
1 = Kgs
2 = Standard sacks
3 = Donkey cart load
4 = Hand cart or wheelbarrow load
5 = Pick-up load
6 = Single line planted 50 m length
7 = Area in acres
8 = Head load
9 = Other (specify)_____

B/26 Did you grow fodder 10 years ago? [ ]=YES [ ]=NO (tick)
If Yes, what was the acreage then (including roadside)? [.]acres.

B/27 Are you a registered member of a dairy co-op or self-help group that collects milk?
[ ]=Dairy coop [ ]=Self-help group [ ]=Not member (tick)
If Yes, since when? [ ] (year)
What is the name of the co-op or group? _____
If Yes, are you currently delivering milk to that co-op or group? [ ]=YES [ ]=NO (tick)
If you are not currently delivering milk, why not? [ ]

0 = Don't have any cows
1 = Immature cows
2 = Dry cows
3 = Sold all cows
4 = Cows died
5 = Selling milk elsewhere at a better price
6 = Consuming all the milk
7 = Dairy co-op collapsed / not taking milk any more
8 = Delayed payments
9 = Other (specify) _____

B/28 What services of the dairy co-op or the Self Help Group do you use? Indicate with ticks.

Services	Dairy co-op	Self Help Group
Milk collection		
Milk processing		
Selling of Inputs		
Provider of AI		
Credit for feeds		
Credit for AI		
Insurance		
Others (specify)_____		

B/29 Have you participated in a zero-grazing project? [___]=YES [___]=NO (tick)
If Yes, which type ? [_____]

1 = Government project
2 = NGO project, specify _____
3 = University project, specify _____
4 = Others (specify) _____

To what level(s) have you participated 1st [____] 2nd [____] 3rd [____]

1 = Training only
2 = Assisted with construction of cattle shed
3 = Obtained cow
4 = Obtained equipment/feeds
5 = Obtained support services (Veterinary, AI, Extension)
6 = Other (specify) _____

B/30. Did you have (cross-bred or pure) dairy animals 10 years ago? [___]=YES [___]=NO (tick)

Do you still have (cross-bred or pure) dairy animals? [___]=YES [___]=NO (tick)

If you no longer have, give reasons why you stopped dairying. [_____][_____][_____]

1 = My animals could not produce more
2 = Dairy animals had poor health
3 = Dairy animals died
4 = Theft of dairy animals
5 = Feed was too expensive
6 = Not enough feed available
7 = Not enough reliable water available
8 = Not enough labour available
9 = Lack of credit to buy animals/feed
10 = I could not sell the milk
12 = I could not use more milk
12 = The price of milk was too low
13 = Other profitable enterprises
14 = Delayed or non-payment from milk buyers
15 = Other cash needs (had to sell animals)
16 = Clashes broke out
17 = Other (specify) _____

SECTION C. LIVESTOCK INVENTORY

C/1. Indicate the numbers of animals for the different species kept on the farm (except cattle)

	Number owned by the household	Number kept but not owned
Goats		
Local		
Dairy (male)		
Dairy (female)		
Sheep		
Poultry		
Local		
Layers (exotic)		
Broilers (exotic)		
Donkeys		
Pigs		
Rabbits		
Bee hives		
Traditional		
Improved (KTBH)		

DOES THE HOUSEHOLD HAVE ANY CATTLE? [___] = YES [___] = NO

IF NO, SKIP EVERYTHING ELSE AND GO TO SECTION H (ON PAGE 183)

C/2 Do you keep written records for your cattle enterprises? [___]=YES [___]=NO (tick)
If yes, which one(s) (list) [___] [___] [___] [___]

1= Breeding records
2 = Production records
3 = Veterinary (treatment) records
4 = Sales and purchases
5 = Deaths and births
6 = Extension visitors book
7 = Other (specify)_____

C/3 What kind of animal identification system for cattle do you use in your farm ? (list)
[___] [___] [___] [___]

1 = None
2 = Name
3 = Tag number
4 = Branding/notching/tattooing
5 = Colour
6 = other (specify) _____

C/4. Local Zebu: Indicate the numbers of local Zebu cattle from each source kept on the farm (including those kept but not owned)

C/5. Dairy cross: Indicate the numbers of dairy cross cattle from each source kept on the farm (including

	Reared on farm	Kept but not owned	Bought from large private dairy farm	Bought from government farm	Bought from smallholder farm/ individual / trader	Loan from project	Gift from relatives/ others	Received as dowry	Other (specify)___
rs)									
dult n, >3									
nales									
ed at									
st-e									
g									
g									

those kept but not owned)

	Reared on farm	Kept but not owned	Bought from large private dairy farm	Bought from government farm	Bought from smallholder farm / individual / trader	Loan from project	Gift from relatives/ others	Received as dowry	Other (specify)___
yrs)									
dult n, >3									
nales									
ed at									
st-e									
g									
g									

C/6. High grade dairy: Indicate the numbers of high grade dairy cattle from each source kept on the farm

E | REASON FOR PURCHASE | BREED
rs or used for service) 1 = Replacement of old animal | 1 =Hostein-Friesian (pure) 7 = Guernsey (pure)

(including those kept but not owned)

iry	Reared on farm	Kept but not owned	Bought from large private dairy farm	Bought from government farm	Bought from smallholder farm/ individual / trader	Loan from project	Gift from relatives/ others	Received as dowry	Other (specify)__
t males (oxen,									
es (<3 yrs)									
at least once)									
weaned, pre									
nales									
'emales									

C/7. Indicate individual details on all cattle that were purchased OR obtained in the last 12 months.
*Number of calvings and State refer only to cows

CATTLE PURCHASED OR OBTAINED (use separate row for each animal)
Use the codes below

Reasons for purchase	Breed	Age (Yrs)	Number of calvings *	State*	Season	Cost (Kshs)	From whom	From Where
[ ][ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]		[ ]	[ ]
[ ][ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]		[ ]	[ ]
[ ][ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]		[ ]	[ ]
[ ][ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]		[ ]	[ ]
[ ][ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]		[ ]	[ ]
[ ][ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]		[ ]	[ ]
[ ][ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]		[ ]	[ ]
[ ][ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]		[ ]	[ ]

rs or used for service)
dult males (>3 yrs)
nales (< 3 yrs)
ng males
ng females

1 = Replacement of old animal
2 = Obtain more manure
3 = Increase social prestige
4 = Increased milk production
5 = Replace animal that died suddenly
6 = For animal draft
7 = Other (specify)________

1 =Hostein-Friesian (pure)
2 =Hostein-Friesian (cross)
3 =Ayrshire (pure)
4 =Ayrshire (cross)
5 = Jersey (pure)
6 = Jersey (cross)
7 = Guernsey (pure)
ernsey (cross)
9 =Sahiwal
10 = Boran
11 = Local Zebu
12 = Other (specify)____

PURCHASE OR OBTAINED FROM WHOM
farm
ot owned
m large private dairy farm
m government farm
m smallholder farm
6 = Bought from individual trader/broker
7 = Loan from project
8 =Gift from relatives/ others
9 = Obtained as dowry
10 = Other (specify)___________

*STATE (cows only)
1 = Dry
2 = Pregnant
3 = Lactating

PURCHASED OR OBTAINED FROM WHERE
1 = Within the sub-location
2 = Within the district
3 = Outside the district

SEASON
1 = Long dry
2 = Long rainy
3 = Short dry
4 = Short rainy

C/8. Indicate, for the last 12 months, individual details on all cattle that were sold or slaughtered.
*Number of calvings and State refer only to cows

CATTLE SOLD or SLAUGHTERED (separate row for each animal) Use the codes below									
Reason for sale or slaughter	Source of animal	Breed	Age (Yrs)	Number of calvings *	State*	Season	Price Received (Kshs)	Sold to whom	Where sold

TYPE
>3 yrs or used for service)
adult males (>3 yrs)
re males (< 3 yrs)

aning males
aning females

(cows only)

REASON
1 = For cash or income
2 = Old age
3 = Disease
4 = Poor performance
5 = Slaughtered for meat
6 = Unwanted (e.g. bull calves)
7 = Ritual / ceremony
8 = Other_____

SEASON
1 = Long dry
2 = Long rainy
3 = Short dry
4 = Short rainy

SOURCE OF ANIMAL
1 = Reared on farm
2 = Kept but not owned
3 = Bought from large private dairy farm
4 = Bought from government farm
5 = Bought from smallholder farm
6 = Bought from individual trader/broker
7 = Loan from project
8 =Gift from relatives/ others
9 = Obtained as dowry
10 = Other (specify)_____

SOLD TO WHOM
1 = Individual
2 = Butcher
3 = Broker/ trader
4 = Other (specify)_____

BREED
1 =Hostein-Friesian (pure)
2 =Hostein-Friesian (cross)
3 =Ayrshire (pure)
4 =Ayrshire (cross)
5 = Jersey (pure)
6 = Jersey (cross)
7 = Guernsey (pure)
8 = Guernsey (cross)
9 =Sahiwal
10 = Boran
11 = Local Zebu
12 = Other (specify)____

SOLD WHERE
1 = Within the sub-location
2 = Within the district
3 = Outside the district

C/9. Indicate, for the last 12 months, individual details on all cattle that died or were stolen.
*Number of calvings and State refer only to cows

CATTLE that DIED or were STOLEN (separate row for each animal) Use the codes below							
imal type	Cause of death/loss	Source of animal	Breed	Age (Yrs)	Number of calvings *	State*	Season

ANIMAL TYPE	CAUSE OF DEATH or LOSS	SOURCE OF ANIMAL	BREED
= Bulls (>3 yrs or used for service)	1 = Old age /natural death	1 = Reared on farm	1 =Hostein-Friesian (pure)
= Castrated adult males (>3 yrs)	2 = Died due to disease	2 = Kept but not owned	2 =Hostein-Friesian (cross)
= Immature males (< 3 yrs)	3 = Died due to injury, accidents	3 = Bought from large private dairy farm	3 =Ayrshire (pure)
= Cows	4 = Died due to poisoning (acaricide, snake bite, bracken fern, etc)	4 = Bought from government farm	4 =Ayrshire (cross)
= Heifers	5 = Died due to bloat	5 = Bought from smallholder farm	5 = Jersey (pure)
= Pre-weaning males	6 = Died due to starvation	6 = Bought from individual trader/broker	6 = Jersey (cross)
= Pre-weaning females	7 = Stolen	7 = Loan from project	7 = Guernsey (pure)
	8 = Neglect (eg bull calves)	8 =Gift from relatives/ others	8 = Guernsey (cross)
	9 = Other _____	9 = Obtained as dowry	9 =Sahiwal
		10 = Other (specify)_____	10 = Boran
			11 = Local Zebu
			12 = Other (specify)____

STATE (cows only)	SEASON
= Dry	1 = Long dry
= Pregnant	2 = Long rainy
= Lactating	3 = Short dry
	4 = Short rainy

SECTION D: FEEDING

D/1. What is your main system for keeping cattle now and what was it 10 years ago, if established then?

	Presently			10 years ago (skip if farm less than 10 yrs)		
Dairy cattle						
Zebu cattle						

1 = Only grazing (free-range or tethered)
2 = Mainly grazing with some stall feeding
3 = Mainly stall feeding with some grazing
4 = Only stall feeding (zero grazing)

D/2. Do you practice Grazing? [___]=YES
[___]=NO (tick)
If Yes, indicate below which types of land are grazed in different seasons (tick).

Source	Long dry season	Long rainy season	Short dry season	Short rainy season	All year
Own pasture/uncropped land	[__]	[__]	[__]	[__]	[__]
Own post harvest cropped	[__]	[__]	[__]	[__]	[__]
Neighbours post harvest cropped	[__]	[__]	[__]	[__]	[__]
Public land	[__]	[__]	[__]	[__]	[__]
Other (specify)_____	[__]	[__]	[__]	[__]	[__]

D/3. Do you cut-and-carry fodder and crop residues to your animals (stall-feeding)?
[___]=YES [___]=NO (tick)

If Yes, indicate which feeds are offered in each season, and whether they are from on or off-farm

	Indicate (using a tick) what periods each feed is offered, and whether mainly from on-farm, off-farm, or both									
	Long dry season		Long rainy season		Short dry season		Short rainy season		All year	
	On farm	Off farm	On farm	Off farm	On farm	Off farm	On farm	Off farm	On farm	Off farm
Napier grass	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other cultivated grass	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Roadside grass	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Forage maize	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Forage sorghum	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Maize stover	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sorghum (millet) stover	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Finger millet stover	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Maize/sorghum thinnings	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Millet straw	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Green maize stover	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Banana fodder	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other crop residues	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Forage legumes	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tree fodders	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other (specify)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

D/4 Which animals receive cut and carry fodder or crop residues (list) 1st [_____] 2nd [_____] 3rd [_____]

1 = All
2 = All cows
3 = Lactating cows
4 = Heifers
5 = Oxen
6 = Calves
7 = Draft animals
8 = Adult bulls
9 = Small ruminants
10 = Others (specify) _____

D/5 Do you feed your animals with Commercial feeds, or Agro-industrial by-products?

[___]=YES [___]=NO (tick)

If Yes, indicate which animals are fed concentrates, the type and amount of concentrate they receive per day, and whether it changes (use the codes below). (DO NOT include poultry)

FILL ONE ROW PER FEED TYPE AND PER ANIMAL TYPE

				Does the quantity increase or decrease:	
				When season changes? 1 = Yes 2 = No	When milk production changes? 1 = Yes 2 = No
	[__]	[__]	[__]	[__]	[__]
	[__]	[__]	[__]	[__]	[__]
	[__]	[__]	[__]	[__]	[__]
	[__]	[__]	[__]	[__]	[__]
	[__]	[__]	[__]	[__]	[__]
	[__]	[__]	[__]	[__]	[__]
	[__]	[__]	[__]	[__]	[__]
	[__]	[__]	[__]	[__]	[__]

CONCENTRATE TYPE
1 = Dairy meal
2 = Maize bran
3 = Wheat bran
4 = Maize germ
5 = Pollard
6 = Oilseed byproducts
7 = Calf pellets
8 = Poultry waste
9 = Pyrethrum marc
10 = Brewer's waste
11 = Other
(specify)_____

ANIMAL TYPE
1 = All
2 = All cows
3 = Lactating cows
4 = Heifers
5 = Oxen
6 = Calves
7 = Draft animals
8 = Adult bulls
9 = Small ruminants
10 = Others (specify) _____

FEEDING UNITS
1 = Kgs
2 = Standard sacks
3 = Donkey cart load
4 = Hand cart/wheelbarrow load
5 = Pick-up load
6 = 1 Kg Kasuku tin or goro-goro
7 = 2 Kg Kasuku tin or goro-goro
8 = Other (specify)_____

D/6. Do you experience a shortage of feeds? [___]=YES [___]=NO (tick)

If Yes, when ? Indicate the corresponding season and tick those when feed shortages are greatest.

	Long dry season	Long rainy season	Short dry season	Short rainy season	All Year
Now	[__]	[__]	[__]	[__]	[__]
10 years ago (skip if farm not established then)	[__]	[__]	[__]	[__]	[__]

D/7. Rank the 3 major strategies (in terms of importance) you apply during these periods of feed shortage and what you did 10 years ago ?. (First - 1, second - 2, third - 3)

Strategy	Now	10 Years ago (skip if farm not established then)
Use standing mature fodder (napier or other)	[__]	[__]
Use cut and stored forages (stover, hay, other crop residues, etc – NOT purchased)	[__]	[__]
Feed less to all animals	[__]	[__]
Feed less to certain categories of animal	[__]	[__]
Feed silage (specify forage type_____)	[__]	[__]
Rent grazing land	[__]	[__]
Take cattle to search for pasture elsewhere	[__]	[__]
Reduce herd size	[__]	[__]
Purchase fodder	[__]	[__]
Purchase concentrate feed	[__]	[__]
Feed tree leaves/forage not normally used	[__]	[__]
Others (specify)_____	[__]	[__]

D/8 How many fodder producing trees do you have of each type?
Indicate either number of trees OR the hedge length of fodder trees.

	Number of trees	Hedge length of trees (metres)
1 = Leucaena	[____]	[____]
2 = Sesbania	[____]	[____]
3 = Grevillea	[____]	[____]
4 = Calliandra	[____]	[____]
5 = Indigenous trees	[____]	[____]
6 = Tithonia	[____]	[____]
7 = Other (specify)_____	[____]	[____]

Since when have you had fodder trees? [__ __ __] (year)
From whom did you get the information on fodder trees? [___] [___] (use codes)

From whom?
1 = Extension service agents/project
2 = Co-operative
3 = Neighbours
4 = Shop
5 = Others (specify) _____

D/9 Do you plant forage legumes? [___]=YES [___]=NO (tick)
If Yes, which forage legumes? (use codes) [___] [___] [___]
Since when did you start growing legumes [__ __ __] (year)
From whom did you get the information on legumes? [___] [___] (use codes)

Forage legumes
1 = Desmodium
2 = Lucerne
3 = Vetch
4 = Microtyloma
5 = Other (specify)_____

From whom?
1 = Extension service agents
2 = Co-operative
3 = Neighbours
4 = Shop
5 = Others (specify) _____

D/10 If you plant maize and/or sorghum indicate the following information :

	Maize	Sorghum
How do plant the crop ?	[ ][ ]	[ ][ ]
Do you plant more than one seed per hole or more seeds per line ? (1 = YES 2 = NO)	[ ]	[ ]
If yes, why ?	[ ][ ]	[ ][ ]
Do you strip (defoliate)the crop? (1 = YES 2 = NO)	[ ]	[ ]
If yes, why ?	[ ][ ]	[ ][ ]
Do you thin the crop ? (1 = YES 2 = NO)	[ ]	[ ]
If yes, why ?	[ ][ ]	[ ][ ]

How do you plant?
1 = in lines
2 = in holes
3 = broadcasting
4 = Other (specify)_____

Why more seeds?
1 = for livestock feeding (when thinning, maize is fed to livestock)
2 = in case one seed does not germinate
3 = to suit the spacing of rows
4 = to produce green maize for sale
5 = other (specify)_____

Why strip (defoliate) leaves and/or thin?
1 = to feed livestock
2 = to use as mulch
3 = to reduce density
4 = other (specify) _____

D/11 Do you ever have difficulties buying feed? [ ]=YES [ ]=NO (tick)

Have you recently searched for new feed sellers? [ ]=YES [ ]=NO (tick

If Yes, why? (list, using codes) [ ][ ][ ]

REASONS FOR SEARCHING FOR FEED SELLERS
1 = Find a better price
2 = Find a single seller of larger quantity
3 = Want more sellers
4 = Find a more reliable seller
5 = Find a better quality
6 = Sellers stopped selling
7 = Other (specify) _____

D/12. If you purchase fodder or concentrates how much did you purchase in the last 12 months and what was the unit price? (If quantity/unit is uncertain record total cost). For the feed sellers, indicate their type, nature of payment, the average distance to the point where you buy, and transport cost.

Feeds types	Units (code)	Quantity Total no. of units	Price per unit (Kshs)	Total cost of purchase	Main Seller Type (code)	Nature of payment (1st seller) (code)	Second Seller Type (code)	Nature of payment (2nd seller) (code)	Average distance to buying point (kms)	Total transpo rt costs
grass										
stover										
stover										
lls										
crop										
lley										
neal										
bran										
germ										
bran										
ucts										
waste										
on										
r's										
lt/salt										

gs
ndard sacks
nkey cart load
nd cart/wheelbarrow load
k-up load
gle line planted 50 m length
ea in acres
ad load
her (specify)_____

Seller type
1 = Individual farmer (s)
2 = Co-op society or farmer group
3 = Trader
4 = Shop
5 = Feed company
6 = Other (specify)
_____

Nature of payment/ contract
1 = Cash sale
2 = On credit sale
3 = Exchange for goods (specify)_____
4 = Other (specify) _____

SECTION E: MILK PRODUCTION AND MARKETING

E/1. When did you first get a dairy/grade cow? [___ ___] (year)
How did you get your first dairy/grade cow? [__] (code)
When did you first get a Zebu cow? [___ ___] (year)
How did you get your first Zebu cow? [__] (code)
When did you first start selling milk ? [___ __ __] (year)

1= Purchased cow from neighbor farmer/ market/ development project
2= Obtained cow from a development project as gift/ loan etc.
3= Through purchased bull on heifer/cow.
4= Through AI on heifer/ cow
5= Through borrowed/rented bull on heifer/cow 6= As a gift from relatives /friends
7= As a loan from relative/friend/ neighbour
8 = Dowry payment
9 = Other (specify) _____

E/2 What are the dominant breed(s) in your herd. 1st [____] 2nd [____](code)

1 =Hostein-Friesian (pure)
2 =Hostein-Friesian (cross)
3 =Ayrshire (pure)
4 =Ayrshire (cross)
5 = Jersey (pure)
6 = Jersey (cross)
7 = Guernsey (pure)
8 = Guernsey (cross)
9 = Sahiwal
10 = Boran
11 = Local Zebu (specify local breed name_____)
12 = Other (specify)____

E/3 Rank the reasons for keeping these particular breeds 1st [____] 2nd [____] 3rd [____] (code)

1 = Better looking animals
2 = Higher milk yields
3 = Better quality milk
4 = Stronger animals for traction
5 = Lack of AI services
6 = Lack of choice semen
7 = Extensionist advice
8 = A condition to getting a loan
9 = Increased status / social standing / personal pride
10 = Hardy: tolerant to diseases
11 = Hardy: tolerant to drought/hunger
12 = Small land holdings or not enough feed
13 = Other (specify) _____

E/4 Have you upgraded your herd (increased the % of dairy genes) during the last 12 months?
[___]=YES [___]=NO (tick)

If NO why not ? [___][___] (code)

1 = Cash problem
2= High cost of improved animals
3= Animals not hardy enough
4 = Animals already 100% exotic
5= Not enough feed/small land holdings
6 = High cost or difficulty of maintenance
7= Logistical problems with AI service
8 = Only heifer on farm/ heat signs
9= Other (specify)_____

E/6. For each COW in the herd up to 3, fill a row. [If number of cows are more than 3 then randomly select 3, including both Zebu and dairy cows.]

	Cow Age (Years)	Number of Calvings	Age at 1st calving (Months)	Pregnant Now? 1=Yes 2=No	Source of last service	Last service date MM/YY (most recent)	Last calving date MM/YY	Second last calving date MM/YY	TOTAL DAILY MILK PRODUCTION (Morning plus evening milk) MILK UNITS: [__] (code)			Date stopped milking MM/YY	MOST RECENT CALF		
									At Calving	Yesterday	When stopped milking		Sex 1=M 2=F	Where is calf?	Age of calf when disposed of in months
]	[__]	[__]	[__]	[__]	[__]	[__/__]	[__/__]	[__/__]	[__]	[__]	[__]	[__/__]	[__]	[___]	[___]
]	[__]	[__]	[__]	[__]	[__]	[__/__]	[__/__]	[__/__]	[__]	[__]	[__]	[__/__]	[__]	[___]	[___]
]	[__]	[__]	[__]	[__]	[__]	[__/__]	[__/__]	[__/__]	[__]	[__]	[__]	[__/__]	[__]	[___]	[___]

BREED		MILK UNITS	
riesian (pure)	7 = Guernsey (pure)	1= Litre	5= "Pint" or Large Cup (500 gm)
riesian (cross)	8 = Guernsey (cross)	2= Kg	6= Small Cup (350 gm)
(pure)	9 = Sahiwal	3= Grams	7= Other (specify)_____
(cross)	10 = Boran	4= Treetop bottle (750ml)	
pure)	11 = Zebu (specify local breed name_____)		
cross)	12 = Other (specify)____	SOURCE OF SERVICE	
		1 = Own bull	5 = Coop / Self Help Gro AI
WHERE IS CALF?		2 = Other farmer's bull	6 = Project AI
on farm	5 = Given out	3 = Government AI	7 = Project bull
	6 = Aborted / still birth	4 = Private AI	8 = Unknown bull
ured	7 = Other (specify) _____		9 = Other (specify)

E/5. Do you plan to increase the amount of milk you produce? [___]=YES[___]=NO (tick)

If yes, how do you plan to do it? First method [ ] Second method [ ] (codes)

1= improve the grade of animals
2= produce more feed
3= buy more feed
4= increase number of dairy cows
5= increase number of dairy goats
6= spend more on controlling animal disease
7= depends on extensionist's advice
8 = better management and feeding practices
9= don't know
10 =Other_____

If NO, why not? Main constraint [ ] Second constraint [ ] (codes)

1= My animals cannot produce more
2= Lack of credit to buy animals/feed
3= I cannot use more milk
4= The price of milk is too low
5= Lack of labour
6 = Not enough feed available for increasing production
7 = Buying more feed would be too expensive
8 = Dairy animals have poor health
9 = I cannot sell more milk
10= There is not enough reliable water available
11= Other specify _____

ASK QUESTIONS E/7 THROUGH E/11 EVEN IF NO CALVES ON FARM PRESENTLY

E/7 How do you feed milk to your calves? [___] (codes)
1 = Let it suckle all day
2 = Restrict the suckling
3 = Bucket feeding

E/8. If you let them suckle, how long do they continue suckling? give a period in months [___]

E/9 At what age in months do you wean the calves and at what age are they sold?
(average of last 3 calves) (put 0 if slaughtered before weaning)

Calves	Age at weaning (months)	Age if sold (months)
Females	[___.]	[___.]
Males	[___.]	[___.]

E/10. Do you castrate male cattle not selected for breeding? [___]=YES [___]=NO (tick

E/11 How many times a day do you milk your cows? Tick where appropriate
3 times [___]
2 times [___]
Once [___]

E/12 Indicate how much of fresh milk you sell now to different types of buyers?
Specify average amount to each type (for example, on an average day during the last week).
Distinguish morning milk from evening milk, and be sure to ask women in the household.

NOW	Buyer Type 1					Buyer Type 2				
PER DAY	Buyer Type 1 (codes)	Milk Unit (codes)	Price/ unit (Kshs)	Avg. quantity sold per DAY (no. of units)	How many buyers of this type? (avg. number)	Buyer Type 2 (codes)	Milk Unit (codes)	Price / unit (Kshs)	Avg. quantity sold per DAY (no. of units)	How many buyers of this type? (avg. number)
Morning milk	[___]	[___]	[___.]	[___]	[___]	[___]	[___]	[___]	[___]	[___.]
Evening milk	[___]	[___]	[___.]	[___]	[___]	[___]	[___]	[___]	[___]	[___.]

TYPES OF BUYERS
1= Individual customers
2= Private milk-traders
3= Private dairy processor
4= Parastatal collection point (KCC)
5= Cooperative collection point
6= Farmer group/club/association
7= Retail shop/kiosks/dukas
8= Hotel/restaurant/office,
9= Institutions: schools/offices/hospitals
10= Other specify_____

MILK UNITS
1= Litre,
2= Kg,
3= Grams
4= Treetop bottle (750ml)
5= "Pint" or Large Cup (500 gm)
6= Small Cup (350 gm)
7= Other (specify)_____

E/13 Please give some information on the same fresh milk buyers listed above:

SAME buyers as in E/12	Buyer type (code)	Average distance to selling point (km)	Who trans-ported? (code)	Trans-port mode (code)	Cost of transport (KsH)	Nature of milk payment (code)	Type of milk test (code)
MORNINGBuyer Type 1	[___]	[_____]	[___]	[___]	[_____]	[___]	[___][___][___]
MORNINGBuyer Type 2	[___]	[_____]	[___]	[___]	[_____]	[___]	[___][___][___]
EVENINGBuyer Type 1	[___]	[_____]	[___]	[___]	[_____]	[___]	[___][___][___]
EVENINGBuyer Type 2	[___]	[_____]	[___]	[___]	[_____]	[___]	[___][___][___]

TYPES OF BUYERS
1= Individual customers
2= Private milk-traders
3= Private dairy processor
4= KCC collection point (KCC)
5= Cooperative collection point
6 = Other (specify)_____

TRANSPORT MODE
1= on- foot
2 = draft animals/ carts
3 = bicycle
4 = public vehicle/ matatu/ bus
5 = private pick-up, van, truck
6 = other (specify)_____

WHO TRANSPORTED?
1 = Farmer (farmer, family or farm labourers)
2 = Buyer
3 = Hired transport (farmer paid)
4 = Hired transport (buyer paid)
5 = Other (specify)_____

NATURE OF MILK PAYMENT
1 = Cash sale - single sale
2 = Cash sale – verbal contract
3 = On credit sale- single sale
4 = On credit sale- verbal contract
5 = On credit sale- written contract
6 = Exchange for goods
7 = Other (specify) _____

TYPE OF MILK TEST
1 = Not checked
2 = Lactometer
3 = Smear test
4 = Smell test
5 = Colour check
6 = Match check
7 = Alcohol gun test
8 = Thermometer test
9 = Other (specify)_____

E/14 Of the milk you produce, indicate how much milk is consumed and or given away now (average per day during the last week). Distinguish morning milk from evening milk.

		Quantity of milk (using same units indicated at left)			
		Consumed by own household	Given to extended family	Given to labourers	Given to neighbours
Morning milk	[___]	[___]	[___]	[___]	[___]
Evening milk	[___]	[___]	[___]	[___]	[___]

MILK UNITS	
1= Litre, 2= Kg, 3= Grams 4= Treetop bottle (750ml)	5= "Pint" or Large Cup (500 gm) 6= Small Cup (350 gm) 7= Other unit (specify conversion rate)_____

E/15 During the long dry season this year (Feb, 2000):
How many liters of milk did you sell on an average day? [___] (liters/day)
What was the price you received per unit of milk? [___] (unit code above)
[___] (Kshs/unit)

E/16 Do you ever make sour milk? (maziwa lala) [___]=YES [___]=NO (tick
If YES, do you ever sell sour milk? [___]=YES [___]=NO (tick)

If YES, how much do you sell on average per day? [___] (liters/day)

If YES, what was the price you received per unit? [___] (milk unit code)
[___] (Kshs/unit)

MILK UNITS
1= Litre,
2= Kg,
3= Grams
4= Treetop bottle (750ml)
5= "Pint" or Large Cup (500 gm)
6= Small Cup (350 gm)
7= Other unit (specify conversion rate)_____

E/17 In which months do you usually sell fresh or sour milk? (circle the months)

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC ALL YEAR NONE

E/18 Do you ever have difficulties selling your milk? [___]=YES [___]=NO (tick)
In the last 12 months, have you searched for new milk buyers? [___]=YES [___]=NO (tick

If Yes, why? (list, using codes below) [___][___][___]

REASONS FOR SEARCHING FOR MILK BUYERS

1 = Find a better price
2 = Find a single buyer of larger quantity
3 = Want more buyers
4 = Find a more reliable buyer
5 = Buyers stopped buying
6 = Other (specify) _____

E/19 Do you ever experience delays in getting paid for milk sold? [___]=YES [___]=NO (tick)

If yes, on average, how long does it take to get paid after delivery?
Indicate number of [___] weeks OR [___] months

How many times in the last 12 months have milk buyers not paid at all? [___] no. of times

SECTION F LIVESTOCK MANAGEMENT AND HEALTH SERVICES

F/1 Do you confine your animals? [___]=YES [___]=NO (tick)
If Yes, where? [___][___] (code)

1 = Stall
2 = Boma or paddock
3 = Tethering
4 = Other (specify) _____

F/2. If you have a paddock, a boma or a stall to enclose your cattle, when did you build it?
[_ _ _ _] (year)

How much did they cost you? (Include costs of expansions and separate dairy shed from boma)

Materials	Cost ofdairy shed (zero-graze unit-KSh)	Cost of boma or paddock (KSh)
Wood		
Cement/Stone/Sand		
Thatch		
Mabati		
Makuti		
Nails		
Fences		
Transport		
Others		
Total		

	Dairy shed	Boma or paddock
How much do you spend per year for its maintenance?	[_ _ _ _] (Kshs)	[_ _ _ _] (Kshs)
From time of construction, how many years do you think it canl last?	[___] (years)	[___] (years)
If you sold the materialsl now, how much do you estimate you can get?	[_ _ _ _] (Kshs)	[_ _ _ _] (Kshs)

F/3. If you are stall-feeding your cows:
under what type of roof are they kept [___] (code)

what is the floor (walking area) of the stall mainly constructed from ? [___] (code)

ROOFING
1= Without roof
2= Under semi-permanent roof ("makuti", thatch etc.)
3 = Under permanent roof (galvanized "mabati" , concrete etc.)

FLOORING
1= Soil
2= Concrete
3 = Stone
4 = Other (specify) _____

F/4. How do you treat your stall floor for collection of manure ? [___][___]

COLLECTION/TREATMENT OF MANURE FROM STALL FLOOR
1 = Clean dung and urine alone regularly
2 = Add feed refusals to dung and urine before cleaning regularly
3 = Collect slurry in pit
4 = Deep litter (let dung, urine, refusals pile in stall for a while before cleaning
5 = Other (specify) _____

F/5. Do you store cattle manure before application to your field? [___]=YES [___]=NO (tick)

F/6. Is water always available to your animals throughout the day? [___]=YES [___]=NO (tick)

F/7. If No, how frequently do you water your cows? [___]

1= Once a day
2= Twice a day
3= Three times a day
4= Other (specify) _____

F/8 Are all your cows provided water with the same frequency? [___]=YES [___]=NO (tick)

F/9 What is the source of this water ?: [___][___] (code)

1= Carted to farm
2= On-farm well / bore hole
3 = Rain catchment
4 = Piped public water supply
5 = Closest river/stream ____
6 = Other (specify)_____

F/10 If you have to collect water what is the distance to the source? [___](kms)

F/11 How often do you feed minerals and/or salt? [___] (code)

1. Ad lib in mineral box
2. Only through concentrate mix
3. Only as salt at weekly/ monthly interval
4. Very occasionally
5. None
6. Other specify _____ _____

What type of minerals and/or salt do you feed? [___] [___] (code)

1= Mineral licks 2 = Common salt / Magadi

F/12 Do you sell manure? [___]=YES [___]=NO (tick)

If Yes, how much did you sell during the last 12 months?
Unit [___] (codes)
Price per unit [___] (Kshs)
No. of units sold [ ]

Indicate the total value sold in last 12 months [___ ___ ___ ___] (Kshs)

MANURE SALES UNITS
1 = Kg
2 = Standard sack
3 = Wheelbarrow
4 = Donkey cart load
5 = Pick-up load
6 = Lorry load
7 = Other (specify)_____

F/13. Have you used anthelmintics in the last 12 months? [___]=YES [___]=NO (tick)
If Yes, please state how used and the number of treatments in the last 12 months

	Adults	Weaners	Suckling Calves	Whole herd
How used? (code)	[___]	[___]	[___]	[___]
Times in last 12 Mo's	[___]	[___]	[___]	[___]

HOW DO YOU USE USE ANTHELMINTICS?
1 = Only on sick animals
2 = As preventive measure

F/14 What are the 3 worst animal health problems affecting your herd (in order)?

	Disease 1	Disease 2	Diseae 3
Which disease? (in order) (codes)	[__]	[__]	[__]
Why is this disease a problem? (list)	[__][__][__]	[__][__][__]	[__][__][__]
Clinical signs (list)	[__][__][__]	[__][__][__]	[__][__][__]
Date when last case occurred (mm/yy)	[__/__]	[__/__]	[__/__]
Breed of animal when last case occurred	[__]	[__]	[__]
Age of animals when last case occurred Indicate units used: 1 = months, 2 = year [__]	[__]	[__]	[__]
Treatment provider of last case (code) Specify name_____	[__]	[__]	[__]
Source of livestock service of last case (code)	[__]	[__]	[__]
Outcome 1 = Died 2 = Survived 3= Slaughtered	[__]	[__]	[__]
Total number of disease events in last 12 months	[__]	[__]	[__]

DISEASES
1 = East Coast fever
2 = Anaplasmosis
3 = Other tick-borne diseases
4 = Respiratory / Pneumonia
5 = Diarrhea
6 = Intestinal worms
7 = Trypanosomosis
8 = Lumpy skin disease
9 = Other skin problems
10 = Mortality in calves
11 = FMD (Foot & Mouth)
12 = Mastitis
13 = Milk fever
14 = Reproduction (abortion, fertility)
15 = Foot problems
16 = Tick burdens
17 = Poisoning (acaricide, snake bite, bracken fern etc.)
18 = Anthrax
19 = Black quarter
20 = Not sure / don't know
21 = Other (specify)_____

BREED
1 =Hostein-Friesian (pure)
2 =Hostein-Friesian (cross)
3 =Ayrshire (pure)
4 =Ayrshire (cross)
5 = Jersey (pure)
6 = Jersey (cross)
7 = Guernsey (pure)
8 = Guernsey (cross)
9 = Sahiwal
10 = Boran
11 = Local Zebu (specify local breed name_____)
12 = Other (specify)_____

Why a problem?
1 = Highest cause of sickness
2 = Causes deaths
3 = decreases milk yield
4 = Affects milking cows
5 = Expensive to prevent
6 = Expensive to treat
7 = Other (specify)_____

CLINICAL SIGNS
1 = Diarrhea
2 = Cough
3 = Fever
4 = Lack of appetite
5 = Skin problems
6 = Swollen lymph nodes
7 = Weight loss
8 = Lameness
9 = Other (specify) _____

TREATMENT PROVIDER OF LAST CASE
1 = None
2= Veterinarian
3 = Animal Health Assistant AHA)
4 = Local traditional herbalists/ quack
5 = Local informal service provider
6 = Neighbour
7 = Self
8 = Other (specify)_____

SOURCE OF LIVESTOCK SERVICE
1 = Government vet dept (on official duty)
2 = Government vet dept (on private duty)
3 = Private vet practice
4 = Local traditional herbalists/ quack
5 = Co-operative
6 = Agrovet shop
7 = Chemist
8 = General shop
9 = Other (specify) _____

F/15. When your animals need health treatment, are services available? [___]=YES [___]=NO (tick)
If Yes, how many times did you use the following in the last 12 months, and what was the total cost including for treatment you administered yourself?

Animal health treatment providers	Diseases treated	Number of yearly visits	Total cost (per year in KSh)
Self/ Neighbour with professional advice	[___][___]	[___]	[_____]
Self/ Neighbour without professional advice	[___][___]	[___]	[_____]
Government veterinarian/AHA	[___][___]	[___]	[_____]
Cooperative Veterinarian/AHA	[___][___]	[___]	[_____]
Project veterinarian/AHA	[___][___]	[___]	[_____]
Private veterinarian/AHA	[___][___]	[___]	[_____]
Traditional herbalist / quack	[___][___]	[___]	[_____]

Total cost includes all expenses, i.e. cost of drugs, professional fees, transport, etc.

DISEASES

1 = East Coast fever
2 = Anaplasmosis
3 = Other tick-borne diseases
4 = Respiratory / Pneumonia
5 = Diarrhea
6 = Intestinal worms
7 = Trypanosomosis
8 = Lumpy skin disease
9 = Other skin problems
10 = Mortality in calves
11 = FMD (Foot & Mouth)
12 = Mastitis
13 = Milk fever
14 = Reproduction (abortion, fertility)
15 = Foot problems
16 = Tick burdens
17 = Poisoning (acaricide, snake bite, bracken fern etc.)
18 = Anthrax
19 = Black quarter
20 = Not sure / don't know
21 = Other (specify)_____

F/16 Have your cattle been vaccinated in the last 12 months? [___]=YES [___]=NO (tick)
If YES against which disease(s) ? (use codes)

	First	Second	Third	Fourth
Zebu	[___]	[___]	[___]	[___]
Grade	[___]	[___]	[___]	[___]

VACCINATIONS

1= Foot and Mouth Disease (FMD)
2= Rinderpest
3= C.B.Pleuropneumonia (CBPP)
4= Anthrax
5= Black quarter
6= Haemorrhagic septicaemia
7 = Lumpy skin disease (LSD)
8 = Brucellosis
9 = Rift Valley Fever
10 = ECF infection & treatment
11 = Don't know
12 = Other (specify)_____

Who provided the vaccinations? [___] (code)

1 = Self
2 = Neighbour
3 = Government veterinarian/AHA
4 = Cooperative Veterinarian/AHA
5 = Project veterinarian/AHA
6 = Private veterinarian/AHA
7 = Traditional herbalist/ quack

F/17 What can ticks do to your cattle if they get into their skin? [___][___] (code)

1 = I dont know
2 = Makes the animal sick
(specify diseases, using code on previous page) [___] [___] [___]
3 = Sucks blood / weakens animal
4 = Damages the hide
5 = Other (specify) _____

F/18 What tick control practices do you use? [___][___][___] (codes)

1= None
2= Acaricide
3= Grazing restriction
4= Hand picking
5= Traditional treatments
6 = Other _____

If acaricide is used, how is it applied, and how frequently?

	Adults: indicate frequency	Young stock: indicate frequency
Dipping	[___]	[___]
Hand spray	[___]	[___]
Hand wash	[___]	[___]
Pour-on	[___]	[___]
Other specify_____	[___]	[___]

FREQUENCY OF ACARICIDE USE
1 = Twice a week
2 = Weekly
3 = Fortnightly
4 = Monthly
5 = Irregularly or occasionally
6 = Other (specify)_____

F/19 Do you have a trypanosomosis disease problem? [___] (codes_

1 = Yes 2 = No 3 = I don't know

If yes, which control measure do you apply for trypanosomosis? [___][___]

1 = No control
2 = Control of Tse Tse flies (traps, etc..)
3 = Use of drugs/chemo-therapeutics
4 = Bush clearing
5 = Use of pour-on, etc (vector control)
6 = Other (specify) _____

F/20 If Trypanosomosis is present but no control measure is employed, why? [___][___]

1 = Do not know where to get drugs
2 = Do not now how to control
3 = Drugs are expensive
4 = Drugs do not work
5 = Other (specify) _____

CREDIT AND LIVESTOCK SERVICES

F/21 Have you ever obtained long term credit (loans) for your dairying activities?

[___]=YES

[___]=NO (tick)

If Yes indicate for which needs credit was obtained, when and from what credit source?
(List each loan separately)

Credit needs (code)	Year obtained	Source of credit (code)	As Money (1) or Materials (2)
[___]	[____]	[___]	[___][___]
[___]	[____]	[___]	[___][___]
[___]	[____]	[___]	[___][___]

CREDIT USES
1= To purchase improved dairy animals
2= For cattle housing
3= For purchase of feed
4 = For veterinary services
5 = For dairy equipment
6 = For establishing fodder
7 = Loan of cattle (heifer in trust, etc)
8= Other specify)_____

SOURCE OF CREDIT
1 = Government bank/agency
2 = Private source
3 = Co-operative
4 = Project / NGO
5 = Self Help group or savings club
6 = Other specify)_____

F/22 If No credit was obtained, why not ? [___] (code)
1 = Credit required but didn't get
2 = Credit not available
3 = Credit was too costly
4 = Lack of collateral
5 = Didn't know / not aware / do not have such information or advice
6 = Fear of being unable to pay
7 = Never thought of it
8 = Other (specify) _____

F/23 Do you get feed on credit, which is deducted from the payment for the milk?
[___]=YES [___]=NO (tick)

If Yes, from whom was feed on credit obtained? [___] (code)
1 = Co-operative or farmer group
2 = Shop
3 = Individual
4 = Other (specify) _____

F/24. Indicate the use and availability of the following services in your area
Note: tick if available, even if not used.

	Available in your area? (tick if available)	Number of visits in last 12 months
AI SERVICES by:		
Government	[ ]	[ ]
Project or NGO's	[ ]	[ ]
Private Practitioners	[ ]	[ ]
Cooperative/farmer group	[ ]	[ ]
EXTENSION SERVICES by:		
Government	[ ]	[ ]
Project or NGO's	[ ]	[ ]
Private Practitioners	[ ]	[ ]
Cooperative/ farmer group	[ ]	[ ]

F/25. What was your total expenditure during the last 12 months on:
Veterinary services [_____] (Kshs)
AI services [_____] (Kshs)
What is the cost (including transport) of one AI service? [_____] (Kshs)

What is the cost (including transport) of one bull service? [_____] (Kshs)

F/26. Which main topic(s) of agriculture, livestock and dairying have you been advised on by Extensionists?
Listl: [___] [___] [___] [___] (codes)

1= Planted forages (napier and other grasses)
2 = Feeding of the dairy cow
3 = Forage/fodder conservation
4 = Breed selection
5 = Milking
6 = Gender awareness
7 = Fodder legumes or trees
8 = Calf rearing
9 = Reproductive management
10= Health management
11= Milk processing
12= Farm judging
13 = Farm management/ economics
14 = Credit
15 = Food crop management
16 = Cash crop management
17 = Others (specify)_____

F/27 How many times in the last 5 years have you attended a dairy field day/seminar ? [___]

How many times in the last 5 years have you attended a general farmer field day/seminar? [___]

SECTION G - FOR NON-AGRICULTURAL HOUSEHOLDS

G/1. What is the total land owned by households in acres (for those not doing agricultural activities):
[__ __ . __] acres

G/2. What is the main use of that land [____]
1= homestead
2= rental
3= business
4= Other (specify)_____

--END OF SECTION FOR NON-AGRICULTURAL HOUSEHOLDS. GO TO SECTION H BELOW.

SECTION H - TO BE ASKED OF ALL HOUSEHOLDS WHETHER A FARMER OR NOT

H/1 If you purchase milk or dairy products, what is the average amount of these products purchased? (consider an average day during the last week)

	Per day or week 1=day 2=week	Unit (code)	Quantity (number of units)	Number of months during the year
Fresh milk	[___]	[___]	[___]	[___]
Sour milk	[___]	[___]	[___]	[___]
Butter	[___]	[___]	[___]	[___]
Yoghurt	[___]	[___]	[___]	[___]
Cheese	[___]	[___]	[___]	[___]

UNITS
1= Litre
2= Kg
3= Grams
4= Treetop bottle (750ml)
5= "Pint" or Large Cup(500gm)
6= SmallCup (350 gm)
7= Other unit (specify conversion rate)

H/2. For the different sources of income to the household , either rank or estimate amount per month or year:
For ranking: 1= main source of income, 2= 2nd , 3 = 3 rd ,4 = smallest source of income

	RANK	INCOME Kshs.	PER MONTH OR YEAR 1=month 2=year
Income from all farm and livestock activities	[__]	[_____]	[__]
Income from wages/salaries/non-farm, pension and business activities	[__]	[_____]	[__]
Income from remittances from absent family members and other external income	[__]	[_____]	[__]
Income from rent (plots, house, etc...)	[__]	[_____]	[__]

H/3. Rank your main types of expenditure, in term of largest per year.
For ranking: 1= largest expenditure, 2= 2nd , 3 = 3 rd , etc

	RANK
Food	[__]
School fees	[__]
Fertilizer	[__]
Livestock feeds	[__]
Livestock drugs	[__]
Family health costs	[__]
Fuel/energy/fuel wood/timber	[__]

H/4: For the different sources of income from the farm activities, either rank or estimate amount per month or year.: FOR FARM HOUSEHOLDS ONLY

For ranking: 1= main source of income, 2= nd , 3= 3 rd , etc

	RANK	INCOME Kshs.	PER MONTH OR YEAR 1=month 2=year
Income from cattle/dairy activities	[__]	[_____]	[__]
Income from sale of cash crop products	[__]	[_____]	[__]
Income from sale of food crop products	[__]	[_____]	[__]
Income from sale of horticultural crops	[__]	[_____]	[__]
Income from sale of fuel wood or timber	[__]	[_____]	[__]
Income from other farm activities (including bee keeping and beer brewing)	[__]	[_____]	[__]

H/5. In which of the following categories do you estimate your total monthly household income, from all farm activities, working members, business income, pensions and remittances from elsewhere

[ ] (code)
Kshs per month
1 = < 2,500
2 = 2,500 - 5,000
3 = 5,000 - 10,000
4 = 10,000 - 20,000
5 = 20,000 - 30,000
6 = > 30,000

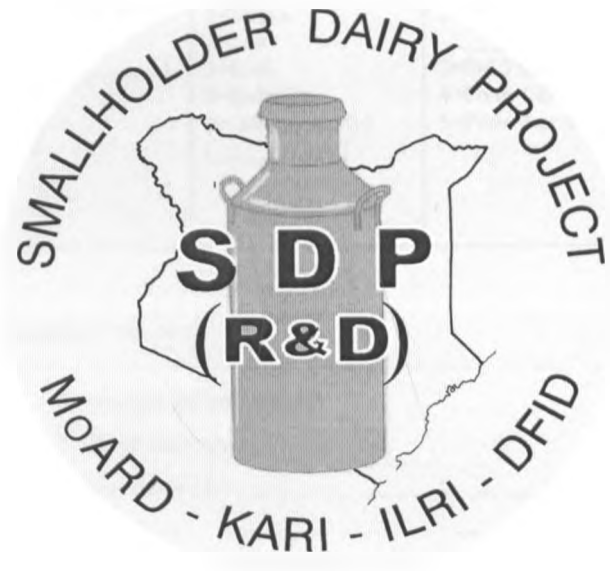
Thank you, Asante ...

Comments:

_____

Appendix 11-B

SMALLHOLDER DAIRY PROJECT (R &D)
Ministry of Agriculture
Kenya Agricultural Research Institute
International Livestock Research Institute



Western Kenya Characterisation Follow-Up Survey

Survey Questionnaire

Questionnaire identification
(To be filled by supervisor at the time of issuing the questionnaire to the enumerator)

Enumerator Name _____
Date of interview (DD/MM/YY/ / / 2002.
District Name _____
Division Name _____
Sub-Location Name _____
Qno: _____
Questionnaire no: _____

SECTION A: ALL HOUSEHOLDS

A/1 Name of the respondent_____

A/2 Indicate the respondent's position in the household (circle)

1=Husband
2=Wife
3=Co-Wife
4=Son
5=Daughter
6=House help/farm labourer
7=Hired Manager
8=Other (specify)_____;

A/3 Details of the household head

is the hold (circle) band ife idow idower n her ify)	Sex (circle) 1=Male 2=Female	Age in years [ ]	Years of farming experience [_____]	Ethnic affiliation (circle) 1=Luhya 2=Luo 3=Kisii 4=Kalenjin 5=Other (specify) [_____]	Education level (circle) 1=No formal education 2=Std 1 through 4 3=Std 5 through 8 4=Form 1 or 2 5=Form 3 or 4 6=Form 5 or 6 7 =Technical college (diploma or certificate) 8=Adult literacy education 9=University 10=Other (specify) [_____.]

A/4 Who is the farm manager? (circle)

1=Husband
2=Wife
3=Co-Wife
4=Son
5=Daughter
6= House help/farm labourer
7= Hired Manager
8= Other (specify) _____.

A/5. Give details of all the household members (including the household head) living permanently on the farm and their primary occupations (on and off-farm). Be sure that all children and infants are included:

Name (first name only)	Age (yrs)	Sex(code) 1=M 2=F	Primary Activities AND/OR Occupations (codes)	Name (first name only)	Age (yrs)	Sex (code) 1=M 2=F	Primary Activities AND/OR Occupations (codes)
1	[ ]	[ ]	[ ][ ]	15	[ ]	[ ]	[ ][ ]
2	[ ]	[ ]	[ ][ ]	16	[ ]	[ ]	[ ][ ]
3	[ ]	[ ]	[ ][ ]	17	[ ]	[ ]	[ ][ ]
4	[ ]	[ ]	[ ][ ]	18	[ ]	[ ]	[ ][ ]
5	[ ]	[ ]	[ ][ ]	19	[ ]	[ ]	[ ][ ]
6	[ ]	[ ]	[ ][ ]	20	[ ]	[ ]	[ ][ ]
7	[ ]	[ ]	[ ][ ]	21	[ ]	[ ]	[ ][ ]
8	[ ]	[ ]	[ ][ ]	22	[ ]	[ ]	[ ][ ]
9	[ ]	[ ]	[ ][ ]	23	[ ]	[ ]	[ ][ ]
10	[ ]	[ ]	[ ][ ]	24	[ ]	[ ]	[ ][ ]
11	[ ]	[ ]	[ ][ ]	25	[ ]	[ ]	[ ][ ]
12	[ ]	[ ]	[ ][ ]	26	[ ]	[ ]	[ ][ ]
13	[ ]	[ ]	[ ][ ]	27	[ ]	[ ]	[ ][ ]
14	[ ]	[ ]	[ ][ ]	28	[ ]	[ ]	[ ][ ]

*A person is a resident if they sleep in the house a majority of nights per week.

Activities and Occupations

1=Farm management/farmer
2=Civil Servant
3=Employee in private sector
4=Business
5=Labour on farm
6=Labour off farm
7a=Housewife
7b=Retired with pension
8=Retired without pension
9=Religious leader
10=In school/college
11=Pre-school age
12=Other (specify) _____

A/6 Indicate who in the household is primarily responsible for carrying out the following tasks

	Main people doing the work are: (see codes below)
Grazing animals	[ ][ ]
Cut and carry of feed	[ ][ ]
Feeding of cattle	[ ][ ]
Milking	[ ][ ]
Milk marketing	[ ][ ]
Spraying/Dipping	[ ][ ]
Cleaning animal shed or boma	[ ][ ]
Obtaining AI/veterinary services	[ ][ ]
Watering the animals	[ ][ ]
Activities related to other livestock	[ ][ ]
Preparing fields for food crops	[ ][ ]
Planting food crops	[ ][ ]
Weeding food crops	[ ][ ]
Harvesting food crops	[ ][ ]
Planting cash crops	[ ][ ]
Weeding cash crops	[ ][ ]
Harvesting cash crops	[ ][ ]

Primary Responsibilities for carrying out tasks

1=Household head
2=Adult males (Other than household head)
3=Adult Females (Other than household head)
4=Children
5=Long-term labourers
6=Casual labourers

A/7. Which form of transport does the household or farm have? (tick) [ ]=None

List codes: Item 1 [____] Item 2 [____] Item 3 [____] Item 4 [____]

1=Bicycle
2=Wheelbarrow
3=Handcart
4=Animal drawn cart
5=Motorcycle
6=Tractor
7=Pickup
8=Car
9=Other (specify) _____

A/8 What is your present land size in acres?[_____]acres

A/8.1 How many plots is your land divided into?[_____]plots.

A/8.2 Of the land you farm or graze but do not own
How much land do you rent from others in acres? [_____]acres
How much communal/public land do you use in acres? [_____]acres

A/8.3 PLOTS TABLE

Note: The definition of a plot is a single piece of land which is connected. Pieces of land not connected are considered separate plots. Make sure that the sum of the proportions equals 1. The first crop indicated has to be a major crop on that land, in terms of density.

	Plot size (acres) [_____]	Land tenure [____] Rented from another? [____]=Yes[___]=No	If rented, rent paid for plot per year [_____]	Distance from homestead (kms) [_____]	
	Crops present (Indicate code)	Proportion of plot 1 allocated to this patch	Is Napier planted on contours? [__]=Yes [__]=No	Use manure? [__]=Yes [ ]=No	Use fertilizer [__]=Yes [__]=No
Patch/cropping mix 1					
Patch/cropping mix 2					
Patch/cropping mix 3					
Patch/cropping mix 4					
Patch/cropping mix 5					
Patch/cropping mix 6					
	Plot size (acres) [_____]	Land tenure [____] Rented from another? [____]=Yes[___]=No	If rented, rent paid for plot per year [_____]	Distance from homestead (kms) [_____]	
	Crops present (Indicate code)	Proportion of plot 1 allocated to this patch	Is Napier planted on contours? [__]=Yes [__]=No	Use manure? [__]=Yes [.]=No	Use fertilizer [__]=Yes [_]=No
Patch/cropping mix 1					
Patch/cropping mix 2					
Patch/cropping mix 3					
Patch/cropping mix 4					
Patch/cropping mix 5					
Patch/cropping mix 6					

	Plot size (acres) [_____]	Land tenure [____] Rented from another? [____]=Yes[___]=No	If rented, rent paid for plot per year [_____]	Distance from homestead (kms) [_____]	
	Crops present (Indicate code)	Proportion of plot 1 allocated to this patch	Is Napier planted on contours? [__]=Yes [__]=No	Use manure? [__]=Yes [_]=No	Use fertilizer [__]=Yes [__]=No
Patch/cropping mix 1					
Patch/cropping mix 2					
Patch/cropping mix 3					
Patch/cropping mix 4					
Patch/cropping mix 5					
Patch/cropping mix 6					

Codes for use in PLOT TABLE A/ 8.3
00=All non- agricultural use of land, including homestead, stores, etc

Food crops	Cash crops	Pasture and Forages
1=arrow root	23=barley	37=desmodium
2=bananas	24=coffee	38=fallow and natural pasture
3=beans	25=cotton	39=fodder beet
4=cabbage, cauliflower	26=cut flowers	40= fodder trees
5=carrots	27=fruit/tree crops	41=lucerne
6=cassava	28=groundnuts	42=napier grass
7=cowpeas	29=pyrethrum	43=oats
8=cucumber	30=rice	44=planted pasture
9=finger millet	31=simsim	45=thatch grass
10=French beans	32=sugarcane(juice)	46=other forage (specify)
11=green paper	33= sugarcane(sugar)	
12=Irish potatoes	34=sunflower	Land Tenure
13=Kale (sukuma)	35=tea	1=traditional
14-maize	36=wheat	2=Freehold (has certificate/title deed)
15=onions		3=leasehold
16=pawpaw		4=informal and not paying rent (e.g roadside)
17=pigeon peas		5=Other (specify)
18=sorghum/millet		
19=soya beans		
20=sweet potatoes		
21=tomatoes		
22=other vegetables		

PLOT TABLE A/ 8.3 (continued)

Note: The definition of a plot is a single piece of land which is connected. Pieces of land not connected are considered separate plots. Make sure that the sum of the proportions equals 1. The first crop indicated has to be a major crop on that land, in terms of density.

	Plot size (acres) [_____]	Land tenure [____] Rented from another? [____]=Yes[___]=No	If rented, rent paid for plot per year [_____]	Distance from homestead (kms) [_____]	
	Crops present (Indicate code)	Proportion of plot 1 allocated to this patch	Is Napier planted on contours? [__]=Yes [__]=No	Use manure? [__]=Yes [_]=No	Use fertilizer [__]=Yes [__]=No
Patch/cropping mix 1					
Patch/cropping mix 2					
Patch/cropping mix 3					
Patch/cropping mix 4					
Patch/cropping mix 5					
Patch/cropping mix 6					
	Plot size (acres) [_____]	Land tenure [____] Rented from another? [____]=Yes[___]=No	If rented, rent paid for plot per year [_____]	Distance from homestead (kms) [_____]	
	Crops present (Indicate code)	Proportion of plot 1 allocated to this patch	Is Napier planted on contours? [__]=Yes [__]=No	Use manure? [__]=Yes [_]=No	Use fertilizer [__]=Yes [__]=No
Patch/cropping mix 1					
Patch/cropping mix 2					
Patch/cropping mix 3					
Patch/cropping mix 4					
Patch/cropping mix 5					
Patch/cropping mix 6					
	Plot size (acres) [_____]	Land tenure [_____] Rented from another? [____]=Yes[___]=No	If rented, rent paid for plot per year [_____]	Distance from homestead (kms) [_____]	
	Crops present (Indicate code)	Proportion of plot 1 allocated to this patch	Is Napier planted on contours? [__]=Yes [__]=No	Use manure? [__]=Yes [__]=No	Use fertilizer [__]=Yes [__]=No
Patch/cropping mix 1					
Patch/cropping mix 2					
Patch/cropping mix 3					
Patch/cropping mix 4					
Patch/cropping mix 5					
Patch/cropping mix 6					

Codes for use in PLOT TABLE A/ 8.3
00=All non- agricultural use of land, including homestead, stores, etc

Food crops	Cash crops	Pasture and Forages
1=arrow root	23=barley	37=desmodium
2=bananas	24=coffee	38=fallow and natural pasture
3=beans	25=cotton	39=fodder beet
4=cabbage, cauliflower	26=cut flowers	40= fodder trees
5=carrots	27=fruit/tree crops	41=lucerne
6=cassava	28=groundnuts	42=napier grass
7=cowpeas	29=pyrethrum	43=oats
8=cucumber	30=rice	44=planted pasture
9=finger millet	31=simsim	45=thatch grass
10=French beans	32=sugarcane(juice)	46=other forage (specify)
11=green paper	33=sugarcane(sugar)	
12=Irish potatoes	34=sunflower	Land Tenure
13=Kale (sukuma)	35=tea	1=traditional
14-maize	36=wheat	2=Freehold (has certificate/title deed)
15=onions		3=leasehold
16=pawpaw		4=informal and not paying rent (eg roadside)
17=pigeon peas		5=Other(specify).
18=sorghum/millet		
19=soya beans		
20=sweet potatoes		
21=tomatoes		
22=other vegetables		

PLOT TABLE A/ 8.3 (continued)

Note: The definition of a plot is a single piece of land which is connected. Pieces of land not connected are considered separate plots. Make sure that the sum of the proportions equals 1. The first crop indicated has to be a major crop on that land, in terms of density.

	Plot size (acres) [ ]	Land tenure [____] Rented from another? [____]=Yes[___]=No	If rented, rent paid for plot per year [_____]	Distance from homestead (kms) [_____]	
	Crops present (Indicate code)	Proportion of plot 1 allocated to this patch	Is Napier planted on contours? [__]=Yes [__]=No	Use manure? [__]=Yes [__]=No	Use fertilizer [__]=Yes [__]=No
Patch/cropping mix 1					
Patch/cropping mix 2					
Patch/cropping mix 3					
Patch/cropping mix 4					
Patch/cropping mix 5					
Patch/cropping mix 6					
Plot 8	Plot size (acres) [ ]	Land tenure [____] Rented from another? [____]=Yes[___]=No	If rented, rent paid for plot per year [_____]	Distance from homestead (kms) [_____]	
	Crops present (Indicate code)	Proportion of plot 1 allocated to this patch	Is Napier planted on contours? [__]=Yes [__]=No	Use manure? [__]=Yes [__]=No	Use fertilizer [__]=Yes [__]=No
Patch/cropping mix 1					
Patch/cropping mix 2					
Patch/cropping mix 3					
Patch/cropping mix 4					
Patch/cropping mix 5					
Patch/cropping mix 6					

Codes for use in PLOT TABLE A/ 8.3
00=All non- agricultural use of land, including homestead, stores, etc

Food crops	Cash crops	Pasture and Forages
1=arrow root	23=barley	37=desmodium
2=bananas	24=coffee	38=fallow and natural pasture
3=beans	25=cotton	39=fodder beet
4=cabbage, cauliflower	26=cut flowers	40= fodder trees
5=carrots	27=fruit/tree crops	41=lucerne
6=cassava	28=groundnuts	42=napier grass
7=cowpeas	29=pyrethrum	43=oats
8=cucumber	30=rice	44=planted pasture
9=finger millet	31=simsim	45=thatch grass
10=French beans	32=sugarcane(juice)	46= other forage (specify).
11=green paper	33= sugarcane(sugar)	
12=Irish potatoes	34=sunflower	Land Tenure
13=Kale (sukuma)	35=tea	1=traditional
14-maize	36=wheat	2=Freehold (has certificate/title deed)
15=onions		3=leasehold
16=pawpaw		4=informal and not paying rent (eg roadside)
17=pigeon peas		5=Other(specify)
18=sorghum/millet		
19=soya beans		
20=sweet potatoes		
21=tomatoes		
22=other vegetables		

A/9. Do you own LIVESTOCK? (tick)
[_____]=Yes [_____]=No

IF NO LIVESTOCK SKIP TO SECTION C

SECTION B: HOUSEHOLDS WITH LIVESTOCK

B/1 Indicate the number of different animals kept on the farm:

	Number kept and owned by the household	Number kept but not owned by the household		Number kept and owned by the household	Number kept but not owned by the household
Cattle breed			7=Guernsey Pure		
1=Friesian Pure			Bulls		
Bulls			Cows		
Cows			Heifers		
Heifers			Calves		
Calves			8=Guernsey Cross		
2=Friesian Cross			Bulls		
Bulls			Cows		
Cows			Heifers		
Heifers			Calves		
Calves			9=Local Zebu		
3=Ayrshire Pure			Bulls		
Bulls			Cows		
Cows			Heifers		
Heifers			Calves		
Calves			Goats		
4=Ayrshire Cross			Local		
Bulls			Dairy (male)		
Cows			Dairy female)		
Heifers			Sheep		
Calves			Poultry		
5=Jersey Pure			Local		
Bulls			Exotic		
Cows			Donkeys		
Heifers			Pigs		
Calves			Rabbits		
6=Jersey Cross			Bee hives		
Bulls					
Cows					
Heifers					
Calves					

IF NO CATTLE SKIP TO SECTION C

B/2 HOUSEHOLDS WITH CATTLE

B/2.1. What are your main objectives for keeping cattle? (rank)

Objective	Rank
Income	
Food supply	
A saving	
Social Prestige	
Cow dung for cementing houses	
Manure for crops	
Other (specify) _____	

B/2.2 What is your system of keeping cattle? (indicate code)

Dairy cattle	[ ]
Zebu cattle	[ ]

1=Only grazing (free or tethered)
2=Mainly grazing with some stall feeding
3=Mainly Stall feeding with some grazing
4=Only stall feeding (Zero grazing)

B/2.3 Which cattle types receive cut and carry fodder or crop residue? (circle)

1=All cattle
2=All cows
3=Lactating cows
4=Heifers
5=Oxen
6=Calves
7=Draft animals
8=Small ruminants
9=Others (specify)_____

B/2.4. Do you have problems when getting feed for cattle? (tick)
[_____]=Yes [_____]=No

B/2.4.1. If Yes what are the problems? (rank)

Difficulties	Rank
1=Transport to carry feed not available	
2=Labour to cut feed not available	
3=Feed not easily available	
4=Buying feed is expensive	
5=Other (specify)_____	

B/3. Have you upgraded your herd (increased the % of dairy genes) during the last 12 months? (tick)
[_____]=Yes [_____]=No

B/3.1 If No, why not? (circle)

1=Cash problem
2=High cost of improved animals
3=Animals no hardy enough
4=High cost or difficulty of maintenance
5=Logistical problems with AI service
6=Other (specify)

B/4 Indicate for the last 12 months, individual details on ALL COWS that died or were stolen.

Cause of Death (indicate code)	Cause of Loss (indicate code)	Source of animal (indicate code)	Breed (indicate code)	Age (yrs)	Number of calvings	State (indicate code)	Season (indicate code)
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ][ ]	[ ]

CAUSE OF DEATH/LOSS	BREED	SOURCE OF ANIMAL	STATE	SEASON
1=Disease	1=Holstein-Friesian (pure)	1=Reared on farm	1=Dry	1=Long dry
2=Old age/natural death	2=Holstein-Friesian (cross)	2=Kept but not owned	2=Pregnant	2=Long rainy
3=Injury/accident	3=Ayrshire (Pure)	3=Bought from private farm	3=Lactating	3=Short dry
4=Poisoning (acaricide, snake bite, bracken fern, etc)	4=Ayrshire (cross)	4=Bought from government farm		4=Short rainy
5=Bloat	5=Jersey (Pure	5=Bought from smallholder farm		
6=Starvation	7=Jersey (cross)	6=Bought from individual trader		
7=Stolen	8= Guernsey (cross)	7=Loan from project		
	9= Guernsey (pure)	8=Gift from relatives/others		
	10=Local Zebu 11=Other (specify)	9=Obtained as dowry		
		10=Other (specify)		

B/5 What are the three worst animal health problems affecting your herd? (in order of severity). (indicate code(s))

	Disease 1	Disease 2	Disease 3
ich disease (in order) (codes)	[_____]	[_____]	[_____]
y is this disease a problem? (list)	[___] [___] [___]	[___] [___] [___]	[___] [___] [___]
ical signs (list)	[___] [___] [___]	[___] [___] [___]	[___] [___] [___]
e when last case occurred (mm/yy)	[__ ____ / ____]	[__ ____ / ____ ____]	[__ ____ / ____ ____]
d of animal when last case occurred	[_____]	[_____]	[_____]
of animals when last case occurred cate units used: 1=months, ear [ ]	[__ __]	[_____]	[_____]
tment provider of last case (code)	[_____]	[_____]	[_____]
ce of livestock service of last case le)	[_____]	[_____]	[_____]
come 1=Died, 2=Survived, aughtered	[_____]	[_____]	[_____]
l number of disease events in the 12 months	[_____]	[_____]	[_____]

B/5

ASES	BREED	CLINICAL SIGNS	WHY A PROBLEM?	TREATMENT PROVIDER OF LAST CASE	SOURCE OF LIVESTOCK SERVICE
				1=None	1= Government department (on official duty)
coast fever	1=Holstein-Friesian (pure)	1=Diarrhea	1=Highest cause of sickness		
plasmosis	2=Holstein-Friesian (cross)	2=Cough	2=Causes deaths	2=Veterinarian	2= Government department (on private duty)
r tick-borne s	3=Ayrshire (Pure)	3=Fever	3=decreases milk yield	3=Animal Health Assistant (AHA)	3=Private vet practise
piratory onia	4=Ayrshire (cross)	4=Lack of appetite	4=Affects milking cows	4=Livestock extension officer	4=Local traditional herbalists /quack
hea	6=Jersey (Pure)		5=Expensive to prevent	5=Agricultural officer	5=Co-operative
inal worms	7=Jersey (cross)	5=Skin problems	6=Expensive to treat	6=Neighbour	6=Agrovet shop
panosomiasis	8= Guernsey (cross)	6=Swollen lymph nodes	7=Other (specify)	7=Self	7=Chemist
py skin	9= Guernsey (pure)	7=Weight loss		8=Other (specify)	8=General shop
r skin ns	10=Local Zebu	8=Lameness			9=Other (specify)
D (Foot and	11=Other	9=Other(specify)			
titis					
k fever					
roduction n, fertility)					
problems					
burden					

B/6 Have you received any animal health services in the last 12 months? (tick)
[_____]=Yes [_____]=No

B/6.1. If yes how many times did you use the following in the last 12 months, and what was the total cost, including cost for treatment you administered yourself?

Animal health treatment providers	Diseases treated (Indicate code(s))	Number of visits	Total cost (per year in Ksh)
Self/neighbour with professional advice	[ ][ ]	[ ]	[ ]
Self/neighbour without professional advice	[ ][ ]	[ ]	[ ]
Government veterinarian/AHA	[ ][ ]	[ ]	[ ]
Cooperative veterinarian/AHA	[ ][ ]	[ ]	[ ]
Project veterinarian/AHA	[ ][ ]	[ ]	[ ]
Private veterinarian/AHA	[ ][ ]	[ ]	[ ]
Traditional herbalist/quack	[ ][ ]	[ ]	[ ]

*Total cost includes all expenses, i.e cost of drugs, professional fees, transport, etc

Diseases treated

1=East coast fever	5=Diarrhea	9=other skin problems	13=milk fever
2=Anaplasmosis	6-Intestinal worms	10=mortality in calves	14=reproduction (abortion, fertility)
3=Other tick-borne diseases	7=Trypanosomiasis	11=FMD (Foot and mouth)	15=Foot problems
4=Respiratory/Pneumonia	8=Lumpy skin disease	12=Mastitis	16=Tick burden

B/7 Have your cattle been vaccinated in the last 12 months? (tick)
[_____]=Yes [_____]=No

B/8. Is water available to your cattle throughout the day?(tick)
[_____]=Yes [_____]=No

B/8.1. If No, how frequently do you water your cattle? (circle)
1=Once a day
2=Twice a day
3=Three times a day
4= Other (specify)_____.

B/8.2. Are all your cattle provided water with the same frequency? (tick)
[_____]=Yes [_____]=No

B/8.3 What is the source of this water? (circle)
1=Piped public water supply
2=On-farm well/bore hole
3=Rain catchment
4=Closest river/stream
5=Other (specify)_____.

B/8.4 If you have to collect water what is the distance to the source? [_____] (kms)

B/8.5 Do you plan to increase the amount of milk you produce? (tick) [_____]=Yes [_____]=No

B/8.5.1 If Yes how do you plan to do it? First method [__] second method [___]
(indicate codes)

1=improve the grade of the animals	4=increase number of dairy cows	7=Better management and feeding practices
2=produce more feed	5=spend more on controlling animal diseases	8=I do not know
3=buy more feed	6=depends on extentionist's advice	9=Other(specify) [ ]

B/8.5.2. If No, why not? Main constraint [__] second method [___] (codes)

1=my animals cannot produce more	5=lack of labour	9=cannot sell more milk
2=lack of credit to buy animals/feed	6=not enough feed available	10= not enough water available
3=I cannot use more milk	7=Buying more feed would be expensive	11=Other (specify) [ ]
4=price of milk too low	8=Animals have poor health	

B/9. Do you sell milk? (tick)
[_____]=Yes [_____]=No

IF NO, SKIP TO B/10.

B/9.1 IF HOUSEHOLD SELLS MILK

Indicate how much of fresh milk you sell now to different types of buyers. Specify average amount of each type (for example, on an average day during the last week). Distinguish morning milk from evening milk, and be sure to ask women in the household.

	Buyer Type 1				Buyer Type 2			
PER DAY	Buyer Type 1 (codes)	Milk Unit (codes)	Price/unit (Kshs)	Average quantity sold per DAY (no. of units)	Buyer Type 2 (codes)	Milk Unit (codes)	Price/unit (Kshs)	Average quantity sold per DAY (no. of units)
Morning milk	[____]	[_____]	[_____]	[_____]	[____]	[____]	[_____]	[_____]
Evening milk	[____]	[_____]	[_____]	[_____]	[____]	[____]	[_____]	[_____]

Types of buyers	Milk units
1=Individual customers	1=Litre
2=Private milk traders	2=kg
3=Private dairy processor	3=Grams
4=Parastatal collection point (KCC)	4=Treetop bottle (750ml)
5=Cooperative collection point	5="Pint" or Large Cup (500gm)
6=Farmer group/club/association	6=Small Cup (350gm)
7=Retail shop/kiosks/dukas	7=Other (specify) [_____]
8=Hotel/restaurant/office	
9=Institutions: schools/offices/hospitals	
10=Other (specify) [_____]	

B/9.2 Please give some information on the same fresh milk buyers listed above. (indicate code)

SAME buyers as above	Buyer type(code)	Average distance to selling point(km)	Nature of milk payment (code)
MORNING Buyer Type 1	[_____]	[_____]	[_____]
MORNING Buyer Type 2	[_____]	[_____]	[_____]
EVENING Buyer Type 1	[_____]	[_____]	[_____]
EVENING Buyer Type 2	[_____]	[_____]	[_____]

Types of buyers	Nature of milk payment
1=Individual customers	1=Cash on delivery
2=Private dairy processor	2=Credit sale
3=Parastatal collection point (KCC)	3=Exchange for goods
4=Cooperative collection point	4=Other (specify)_____
5=Farmer group/club/association	
6=Retail shop/kiosks/dukas	
7=Hotel/restaurant/office	
8=Institutions:schools/offices/hospitals	
9= Other (specify)_____	

B/ 9.3 Of the milk you produce indicate how much milk is consumed or given away now (average per day during the last week)

Distinguish morning milk from evening milk.

		Quantity of milk				
PER DAY	Milk Unit (Indicate code)	Consumed by own household	Given to extended family	Given to labourers	Given to neighbours	Given to calves
Morning milk	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]
Evening milk	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]

Milk units	
1=Litre	5="Pint" or large Cup (500 gm)
2=Kg	6=Small Cup (350 gm)
3=Grams	7=Other unit (specify) _____
4=Treetop bottle (750 ml)	

B/9.4 Do you have difficulties selling your milk? (tick)
[_____]=Yes [_____]=No

B/9.4.1 If Yes what are the problems? (rank)

Problem	Rank
1=Problem in getting a buyer	
2=Buyers unreliable	
3=Delays in milk payment	
4=Transport to the market	
5=Low milk prices	
6=Other (specify) _____	

B/9.5 Do buyers prefer milk from any particular breeds? (tick)
[_____]=Yes [_____]=No

B/9.5.1 If Yes what breeds are preferred? (circle)

Breed

1a=Holstein-Friesian (pure) 6=Guernsey (cross)

1b=Holstein-Friesian (cross) 7=Guernsey (pure)

2=Ayrshire (Pure) 8=Local Zebu

3=Ayrshire (cross) 9=Other(specify)_____.

4=Jersey (Pure

5=Jersey (cross)

B/9.5.2. Why do buyers prefer milk from these particular breeds? (circle)
1=The cream is thicker
2=The taste is better
3=The colour is desirable
4= Other(specify) _____.

B/10 IF HOUSEHOLD DOES NOT SELL MILK:

B/10.1 What are the reasons for not selling milk? (rank)

Reason	Rank
1= No Surplus for sale	
2= No market to sell milk	
3= Price of milk is low	
4= Buyers unreliable	
5= No transport to the market	
6= Other (specify) [ ]	

SECTION C: HOUSEHOLDS WITHOUT CATTLE

C/1 Have you had cattle before? (tick)
[_____]=Yes [_____]=No

C/1.1 If Yes, what are the reasons for not keeping cattle now? (rank)

Reasons	Rank
1= Limited land	
2= Lack of labour	
3= Lack of money to buy cattle	
4= Lack of feed	
5= Lack of interest	
6= Lack of Extension services	
7= Sold cattle to meet cash needs	
8= Other (specify) [ ]	

C/1.2 If No, what are the reasons for not ever keeping cattle (rank)

Reasons	Rank
1= Limited land	
2= Lack of labour	
3= Lack of money to buy cattle	
4= Lack of feed	
5= Lack of interest	
6= Lack of Extension services	
7= Other (specify) [ ]	

SECTION D: ALL HOUSEHOLDS

D/1. Do you receive extension services? (tick)

[_____]=Yes [_____]=No

D/1.1 If Yes what extension topics are covered? (circle)

1= Crop management
2= Feeding of the dairy cow
3= Forage/fodder management
4= Breed selection
5= Milking
6= Animal health management
7= Farm management
8= Other (specify) [_____]

D/2 Have you participated in a Zero-grazing project? (tick)

[_____]=Yes [_____]=No

D/2 .1 If Yes, which type? (circle)

1=Government project
2= NGO project (specify) _____.
3=University project (specify)_____.
4=Other (specify)_____.

D/2.2 To what level(s) have you participated in the Zero-grazing project (indicate code)

1st [_____] 2nd [_____] 3rd [_____]
1=Training only
2= Assisted with construction of cattle shed
3=Obtained cow
4=Obtained equipment/feeds
5=Obtained support services (Veterinary, AI, Extension)
6= Other (specify)_____.

D/3. How do you use your farm crop residue? (circle)

1= Left on the farm
2= Used as feed for own cattle
3= Other (specify) [_____]

D/3.1 Do you grow Napier grass? (tick)

[_____]=Yes [_____]=No

D/3.2. If Yes what is the total acreage?_____ acres

D/3.3 Do you use manure or cattle slurry? (tick)

[_____]=Yes [_____]=No

D/ 3.3.1 If Yes, where do you use it? (circle)

1=applied to food crops
2=applied to cash crops
3=used for cementing houses
4=Other (specify) [_____]

D/ 3.3.2 If you use own manure from which animals is it obtained? (circle)

1= Local cattle
2= Grade cattle
3= Poultry
4= Pigs
5= Other (specify) [_____]

SECTION E: ALL HOUSEHOLDS

Suppose 5 local (indigenous) cows have the same financial value as 1grade cow, and all the 5 local cows together produce the same amount of milk as 1 grade cow:

E/1.1 What choice would give you a higher social status? (circle)

1=5 local cows
2=1 grade cow
3=None

E/1.2 What choice would you make if you were to pay bride price? (circle)

1=5 local cows
2=1 grade cow
3=None

E/1.3 If you were to receive a gift what choice would you make? (circle)

1=5 local cows
2=1 grade cow
3=None

E/2 Do you prefer milk from any particular breeds? (tick)

[_____]=Yes [_____]=No

E/3 If Yes from what breeds do you prefer? (circle)

Breed

1a=Holstein-Friesian (pure)
1b=Holstein-Friesian (cross)
2=Ayrshire (Pure)
3=Ayrshire (cross)
4=Jersey (Pure
5=Jersey (cross)
6=Guernsey (cross)
7=Guernsey (pure)
8=Local Zebu
9=Other (specify)[_____]

E/4 Why do you prefer milk from these particular breeds (circle)

1=The milk cream is thicker
2=The taste is better
3=The colour is desirable
4= Other (specify)[_____]

E/5 Does the colour of the cows matter? (tick)

[_____]=Yes [_____]=No

E/6 If Yes what colours do you look for? (specify) [_____]

E/8 Rank the different SOURCES OF INCOME (rank)

1=main source of income, 2==2nd, 3=3rd, 4th =smallest source of income

Main Source	Rank
Income from all farm and livestock activities	
Income from wages/salaries/non-farm, pension and business activities	
Income from remittances from absent family members and other external income	
Income from rent (plots, house etc)	

E/9. Rank the different SOURCES OF FARM INCOME (rank)

1=main source of income, 2=2nd, 3=3rd, 6th =smallest source of income

Income	Rank
Income from cattle/dairy activities	
Income from sale of cash crops	
Income from sale of food crops	
Income from sale of horticultural crops	
Income from sale of fuel wood or timber	
Income from other activities (bee keeping, beer brewing)	

E/10. In which of the following categories do you estimate your total monthly income (in Kshs), from all farm activities, working members, business income, pension and remittances from elsewhere. (circle)

1=<2,500
2=2,500-5,000
3=5,000-10,000
4=10,000-20,000
5=20,000-30,000
6=>30,000

SECTION F

F/1 The Experimental Design

Please rank the following attributes of a dairy cow:

(Rank from 1 as the most preferred to 5 as the least preferred)

(USE THE 5 CARDS GIVEN)

Block1	
	Rank
C- 1	
C- 2	
C- 3	
C- 4	
C- 5	

Block2	
	Rank
C- 6	
C- 7	
C- 8	
C- 9	
C- 10	

Block3	
	Rank
C- 11	
C- 12	
C- 13	
C- 14	
C- 15	

Block4	
	Rank
C- 16	
C- 17	
C- 18	
C- 19	
C- 20	

Block5	
	Rank
C- 21	
C- 22	
C- 23	
C- 24	
C- 25	

Block6	
	Rank
C- 26	
C- 27	
C- 28	
C- 29	
C- 30	

Block7	
	Rank
C- 31	
C- 32	
C- 33	
C- 34	
C- 35	

Block8	
	Rank
C- 36	
C- 37	
C- 38	
C- 39	
C- 40	

Block9	
	Rank
C-41	
C 42	
C-43	
C-44	
C-45	