

**CHARACTERIZATION OF SMALLHOLDER DAIRY  
PRODUCTION AND MARKETING SYSTEMS ACROSS  
DIFFERENT SITES IN KIAMBU DISTRICT, KENYA.**

By

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**A thesis submitted in partial fulfillment of the requirements for the degree of  
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## DECLARATION

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

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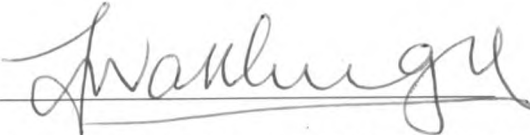
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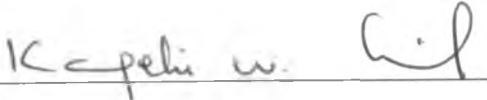
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## **DEDICATION**

**To all farmers who take time and energy to keep records of all financial and non-financial transactions in their farms.**

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## LIST OF ABBREVIATIONS AND ACRONYMS

AD:	Agricultural Dependent
APSK:	Animal Production Society of Kenya
ASFRE:	Association of Farming Systems Research
CBS:	Central Bureau of Statistics
DFID:	Department for International Development
Ed (s):	Editor(s)
FAO:	Food and Agriculture Organization of United Nations
G/C:	Grade/ crossbred cow
GDP:	Gross domestic product
GoK:	Government of Kenya
IFPRI:	International Food Policy Research Institute
ILCA:	International Livestock Centre for Africa
ILRI:	International Livestock Research Institute
ITM:	Infection and Treatment Method
KARI:	Kenya Agricultural Research Institute
KES:	Kenya shillings
kg:	Kilogramme
LADA:	Land Degradation Assessment in Dry lands
M.Sc:	Master of Science degree
MoA:	Ministry of Agriculture
MoALD&M:	Ministry of Agriculture, Livestock Development and Marketing
MoARD:	Ministry of Agriculture and Rural Development

NAD:	Non-Agricultural Dependent
NDDP:	National Dairy Development Project
°C:	Degrees Celsius
P.G.D:	Post Graduate Diploma
P.G.D.E:	Post Graduate Diploma in Education
PhD:	Doctorate of Philosophy degree
R & D:	Research and Development
s.S.A:	sub-Saharan Africa
SDP:	Smallholder Dairy Project
SPSS:	Statistical Programme for Social Scientists

## ABSTRACT

To characterize smallholder dairy production systems across different agro-ecological zones in Kiambu district, identify constraints and opportunities to improve profitability by optimizing resource use based on key determinants to make decisions on choice of appropriate risk management (production and marketing) strategies data was collected through households' survey. The methodology used for data collection through purposive multi stage design using Probability Proportion to Size (PPS) sampling design was based on a conceptual framework for dairy systems analysis of production-to-consumption approach developed by ILRI. One hundred and thirty four smallholder dairy households were randomly selected in three agro-ecological zones namely: lower highlands, upper midlands and lower midlands in Limuru, Kiambaa and Ndeiya divisions respectively.

Principal components analyses and cluster analysis were used to classify smallholder farms in terms of risk management strategies, level of household resources, level of dairy intensification and level of access to services and markets. Four classes of dairy system clusters were identified. The results showed that 41.8% and 35.1% of farmers either marketed their milk through the cooperatives and informal marketing channels respectively. Policies to improve the operational and pricing efficiencies of dairy cooperatives would have a self-accelerating effect on productivity. Informal milk marketing channels operate without a legal framework. Regulations to guide their operations should be formulated.

Econometric logit models were used to analyze the determinants of small-scale dairy farmers' adoption of various production and marketing strategies. Logit models of

changes in livestock numbers, use of purchased concentrate feeds and forage management practices, routine animal health and veterinary services were non-significant ( $p > 0.05$ ). However, logit model of milk marketing through cooperative channel was significant ( $p < 0.05$ ).

Eleven explanatory variables were significant ( $p < 0.05$ ) in explaining smallholder farmers' adoption of milk marketing through the cooperative channel. Lower midlands, leased land, price of milk (KES /kg) and total farm acreage negatively influenced farmers' adoption of milk marketing through the cooperative channel. Lower highlands, hired permanent labour, number of cows milked, average milk production per cow (kg/day), dairy cooperative as a source of animal production information, household head worked off-farm and availability of credit services had positive influence.

The farm profit formula was used to estimate the costs of production and returns (KES /kg) of milk produced. Fixed costs were ignored since were unrelated to higher levels of milk production and do not affect the optimal combination of the variable inputs. Majority of Kenyans' small-scale farmers own most of their fixed costs and can therefore make decisions based on profits only. The computation of production costs and revenues (from the milk sold or consumed by households and calves) were based on the dairy enterprise only. The results showed that the cost of production and unit profit were 16.90 and 6.30, 19.05 and 2.30, and 18.05 and 3.45 KES /kg of milk produced in upper midlands, lower highlands and lower midlands respectively. These estimates of costs of production and returns are important for policy makers and development planners when



making decisions related to availability and cost of any risk management strategy in dairy enterprise.

In addition, there were no significant differences ( $p > 0.05$ ) between costs of production in the three agro-ecological zones. This was a reflection of similarities in levels of intensification in the three agro-ecological zones. However, the variations of returns (KES/ kg) of milk were significant ( $p < 0.05$ ) between lower highlands and upper midlands, an indication that farmers in the later agro-ecological zone were making much more profit from milk than those in the former probably due to higher milk prices. The survey showed that dairy enterprise was the most important income generating farming activity in 96.7% of households in Kiambu district and probably the most important farming activity in the Kenya highlands.

## 1.0: INTRODUCTION

### 1.1: Background

Livestock is the world's largest user of land either directly through grazing or indirectly through consumption of fodder, crop residues and feed grains. Globally, livestock production currently accounts for some 40% of the gross value of agricultural production (Bruinsma 2003).

In sub-Saharan Africa (s.S.A), animal products account for 25% of the value of all agricultural products, and of this milk accounts for 46%. Livestock thus sustain the employment and income of millions in sub-Saharan Africa, 70% of who are rural based (Winrock International 1992).

Livestock make an important contribution to most households in Kenya. The livestock sub-sector accounts for about 42% of Kenya's agricultural gross domestic product (GDP) and 10% of the national GDP and supplies domestic requirements of meat, milk and dairy products and other livestock products. Livestock products further account for 30% of the total marketed agricultural products (Gitu 2004).

The Kenyan dairy sector is made up of more than 600,000 smallholder dairy farms scattered around the country. These farmers account for 56% of the total milk production and 70% of the total marketed milk in the country (Omoro *et al.*, 1999 and GoK 2004). Furthermore, livestock diversify production; provide year-round employment and spread of risk. Livestock also form a major capital reserve of farming households. These contributions to the economy transcend food production to include multipurpose uses such as skins, hides, fibres, fertilizers, drought, leisure and fuel (Gitu 2004).

Kenya has a large and diverse livestock resource base estimated to be over 60 million comprising 29 million chicken, 10 million beef cattle, 3 million dairy and dairy crosses, 9 million goats, 7 million sheep, 800,000 camels, 520,000 donkeys and 300,000 pigs. There are also unspecified numbers of non-conventional livestock species (GoK 2004). They occupy 3,240,000 ha, which is 47.4% of the percentage total of land utilization for agricultural production.

To characterize smallholder dairy production systems across different sites in Kiambu district, identify constraints and opportunities to improve profitability by optimizing resource use based on key determinants to make decisions on choice of appropriate risk management data was collected through households' survey. The study used conceptual framework for dairy systems analysis of production-to-consumption approach developed by ILRI (Rey *et al.*, 1993).

Any factor that could lower or increase expenses is a source of risk to the economic performance of the dairy business (Bailey 2001). There are many sources of risk on today's dairy farming that could adversely affect profit. Some of these risks are: milk prices, purchased feed prices, hired labour, crop /forage production among others. Uncertainty, unlike risk, is a situation where probabilities of future outcomes cannot be established on empirical or quantitative evidence (Newbery *et al.*, 1981). Uncertainty is always present when knowledge of the future is less than perfect in the sense that the probability distribution (the mean yield or price) cannot be predicted.

## 1.2: Problem Statement

Dairy production is faced by a multitude of perceived and often experienced risks, which contribute to high costs of production and low average productivity (Omore *et al.*, 1997, Kaguongo *et al.*, 1997 and Tanner *et al.*, 1998). The choice of production and marketing strategies on farms contribute to high costs of production, low productivity and inefficient market system for milk. These factors cause low profit to the producer and price fluctuations for the consumer (Muriuki *et al.*, 2003). The risk attitudes held by the farmers may reduce the rate of uptake of any technology, if it is perceived to contradict risk management strategies employed by the farmers, regardless of the potential returns (Anderson *et al.*, 1992).

The choice of any risk management strategy in a particular agro-ecological zone may be influenced by several factors, such as agricultural potential, access to markets, population density, and presence of government programmes and organizations (Todaro 2000 and Benin *et al.*, 2003). These factors influence the awareness, availability, costs, benefits and risks associated with different livestock technologies and management practices (Benin *et al.*, 2003).

Farmers operating under zero grazing systems in Kiambu district face, a multitude of perceived and often experienced risks of varying severity that emanate from the uncertainties inherent in their natural, economic and socio-political environments. In addition, some of the main constraints to increased milk production have been identified as inadequate quantity and quality of feed, including limited use of concentrates, and poor access to breeding, veterinary and credit services. In some areas, poor access to output markets reduces the incentives to increased milk production (Muriuki *et al.*, 2003).

Therefore, farmers do struggle with risky decisions throughout the year. Further, these constraints are considered to be partly associated with the inability of policies and responsible institutions to serve the interest of farmers.

These are expected to determine the choice of any risk management strategy and affect the cost of production and returns (KSE/ kg) of milk produced in Kiambu district. To increase adoption rate of intensive dairying such as increased concentrate feeding and health services by smallholder farms, it is important to determine the source of risks in these farms and assess coping strategies employed by the farmers. Therefore, the determinants of adoption of risk management strategies and effect of these strategies on performance on dairying at farm level must be evaluated.

### **1.3: Objectives**

The broad objective was to characterize smallholder dairy production systems across different sites in Kiambu district, identify constraints and opportunities to improve profitability by optimizing resource use based on key determinants to make decisions on choice of appropriate risk management.

Specific objectives of the study were to:

- (i) characterize the smallholder dairy production and marketing systems in the area to allow better targeting of future dairy research and development programmes.
- (ii) identify the determinants of smallholder dairy farmer's adoption of various risk management strategies used in Kiambu district.
- (iii) estimate the costs of production and returns ( KES / kg) of milk produced.

## 1.4: Hypotheses

The following are the four hypotheses tested in this study

- (i) That the prospects for any sustainable risk management strategy in any particular location depend on common patterns of change in livelihood.
- (ii) Farmers have not adopted modern risk management strategies because they are unaware of their existence.
- (iii) That the set of policy-related interventions like extension and credit do not significantly affect farmers' risk management strategy.
- (iv) That the cost of risk management strategies does not affect the cost of production and returns in KES / kg of milk produced.

## 1.5: Significance of the Study

Most studies in smallholder livestock production have focused on the optimization of resource use, and constraints and general social economic factors affecting productivity and marketing in dairy enterprise in Kenya (Muriithi 1990, Echessah 1994, Isaboke 1995 and Kaguongo *et al.*, 1997). Studies have been done on returns (KES/ litre) of milk produced (Sellen *et al.*, 1990, Mogaka 1995, Maina *et al.*, 1995 and Staal *et al.*, 2003).

Other surveys have been conducted to determine the types of risks faced by dairy farmers and the risk management strategies that they use (Nyangito 1992, Schaik 1995, Kaguongo *et al.*, 1997 and Nicholson *et al.*, 1999). However, studies to analyze the determinants of smallholder dairy farmer's adoption of various risk management strategies and their effects on profitability in smallholder dairy cattle herds are limited.

To formulate sound policies and actions, improve the dairy sub-sector, it is important to identify factors affecting smallholder dairy farmer's adoption of various risk management

strategies and their effects on profitability in smallholder dairy enterprises. There is paucity of information on benefit-cost analysis of risk management strategies, though perceived to be high in the smallholder farmers in Kiambu district.

In addition, since policy choices and market phenomena beyond the farm gate influence almost every aspect of dairy farm management, any appraisal of the possibilities of risk mitigation requires awareness of these effects. The typical risk management strategies that the study will examine are changes in ownership of livestock, use of animal health and veterinary services, purchased feed and feed resources, availability and quality of forages and adoption of improved breeds and modern management techniques.

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## 2.0: LITERATURE REVIEW

### 2.1: Risks and risk management strategies

Agriculture is subject to all manner of risks which involves changes in farmer's decision process that considers the events that are likely to occur and outcomes are expected, probabilities of each event's occurrence and a procedure for ranking alternatives (Sonka *et al.*, 1984). The individual farmer is prone to production and price risks. Production risks affect individual farmer's output and arise due to variations in weather, the prevalence of pests and disease and other natural causes, such as fire (Bruinsma 2003). Price risks affect the prices an individual farmer receives for goods produced or the inputs to be purchased. The output price risk is the most important for the farmer's decision making (Newbery *et al.*, 1981).

Rural households in many parts of sub-Saharan Africa typically face considerable risks because of weather and price variability, crop and animal diseases, and pest attacks (Binswanger *et al.*, 1987). Over the lifetime of a household, there is usually a succession of environmental crises and catastrophes challenges and changes. Positive opportunities, such as technological innovations, will appear and be available for uptake. Decision makers will review each and on the basis of whatever information is at hand, personal judgment made about the desirability of the innovation and the extent and time of possible exploitation. Particularly when they first come to their notice, farmers feel that some innovations, add more risk to their operations than they add to anticipated gains on average (Anderson *et al.*, 1992).

At village level, risk management issues include the different kinds of land available, the overall population pressure on farmland and its availability, access to grazing and forage

resources, the importance of labour flows between households, as well as location in relation to market FAO (2003). At national level, factors of relevance relate to macro-economic policy, input-output prices ratios, access to credit, institutions regarding land tenure and management, approaches to research and extension policy, markets and infrastructure (Muriuki *et al.*, 2003).

Risk in farming arises because a farmer, when embarking on any productive activity, is uncertain about what the actual outcome will be. This is particularly so in the tropics, with unreliable rains, possible major pest and disease outbreaks, and widely fluctuating market prices where farmers' goals are often poorly defined (Ruthenberg 1985). A different type of uncertainty that may also have important implications for crop- livestock development is strategic uncertainty associated with imperfect knowledge of the response of other members of a community to collective action. For example, livestock, even in sedentary systems, depend on common-pool resources (for example, rangeland and water points) found around villages (Bromley *et al.*, 1989).

The use of some technologies involves externalities. A farmer's use of veterinary drug or vaccine results in positive externalities, because it reduces the risk of livestock disease transmission to neighbouring animals (Umali *et al.*, 1992), while inappropriate pesticide use can result in the negative externalities of pesticide pollution, pest resistant, and various health hazards. There are also moral hazards associated with use of some of these technologies. For example, it may be difficult to visibly assess the difference between a good or bad seed, between an effective or ineffective livestock pharmaceutical drug, or between an adulterated and pure agricultural chemical. In many cases, clear conceptual

relationships exist between different technologies for example, zero grazing and improved fodder technologies (Plance *et al.*, 2002).

Risk in agricultural production carries four basic consequences for a market economy. First, physical output is contingent on the state of nature that happens to be realized at any particular moment. Second, partly as a consequence of the randomness of yields and partly due to operated attempts at making production plans based on forecast, prices are stochastic too. The complexity of this process is increased significantly if risk enters multiplicatively rather than additively. Third, attitude towards risks of other than neutral, are important in determining production levels. Further trade performance market clearing, at balance of payments equilibrium can only be judged by suitable statistic and do not hold invariably except in a trial ex post sense (Anderson *et al.*, 1992).

Sonka *et al.*, (1984) classified sources of risks into five major groups, namely: production or technical risk; market or price risk; technological risk; legal and social risk and human sources of risk. They grouped risk responses into two types; one concerning action for reducing the effects of risk in the farm business and the other one involving changes in a farmers' decision process. Consequently, an action is considered risk reducing, if when repeated numerous times, it lowers the variability and the expected level of income compared to the alternative action. However, if an action both reduces income variability and increases expected income, it is unclear if such a decision made to reduce risk or to increase profit.

Most agricultural economists would agree that farmers' attitudes towards risk are quantitatively important determinants of their decision making, especially in less

developed countries where risks are relatively larger, incomes lower, and risk spreading options fewer (Timothy *et al.*, 2000). Econometric studies of peasants' risk attitudes are usually based on the observed gap between expected revenue and marginal costs (Antle 1989). In literature much normative analysis (with mathematical programming etc) has been done to show how farmers should behave under uncertainty (Hardaker *et al.*, 1997).

In USA, farmers including dairy farmers are most concerned about price risk, production risk and changes in government laws and regulations (Harwood *et al.*, 1999). Arizona dairy farmers perceived the costs of operating inputs to be the greatest source of risk (Wilson *et al.*, 1988). Keeping cash on hand was the number one risk management strategy for every size farm, for every commodity specialty. Use of derivative and insurance markets were also considered important.

Dutch livestock farmers considered price and production risks to be the most important (Huirne *et al.*, 2000 and Meuwissen *et al.*, 2001). Producing at lowest possible costs and insurance were the most important risk management strategies for these farmers. Norway farmers considered institutional risk as the most important source of risk, independently of conventional or organic production systems, while organic farmers indicated greater concern about forage yield risk (Gudbrand *et al.*, 2003). Keeping cash in hand was the most important strategy to manage risk for all dairy farmers. Diversification and different kinds of specialty were regarded as more important risk management strategies among organic than conventional farmers.

## 2. 11: Approaches to managing risk

Farmers have developed quite sophisticated approaches to managing their risks. In the broadest term the producer management devolves to the pursuit of potentially complementary themes- diversify, flexibility, productivity and stability. Effective marketing systems for farm inputs and outputs must thus be seen as a necessary if not sufficient for improving the possibilities of small-scale farmers to manage their risks (Anderson *et al.*, 1992). Even within a single farm, the management of land may vary considerably between different fields. Typically, certain fields tend to receive far greater concentrations of labour and nutrients inputs, while others are more extensively managed (FAO 2003).

Many factors potentially affect farmers' decision about livelihood strategies and land management (Todaro 2000 and Benin *et al.*, 2003). The options available to small-scale farmers to improve their land are much more constrained than those are available to rich farmers who have easier access to labour, livestock, land, credit and cash (FAO 2003). Typically, the family farmer in developing countries is thought to be risk averse, which means he is willing to forego some income on average in order to avoid risk (Pinstrup-Anderson 1982) and by insurance against natural hazards.

Some of the approaches to managing risks do rely on either markets or government and linkages between them (Benin *et al.*, 2003). Intervention markets vary greatly in nature's purpose and function and surprisingly those oriented to farm-level risk mitigation are exceptionally diverse. They range from informal reciprocal arrangements for helps amongst extended families, friends, and members of rural communities with no



immediate expectation of repayments, whether in cash, through to explicit market arrangements based on informal commercial contracts (Anderson *et al.*, 1992).

Traditional methods of handling risk can be divided into risk minimizing mechanism and loss net mechanism. Risk minimizing practices are adjustments to production and resource use before and during a production season (Frankenberger *et al.*, 1990). This involves practices such as diversification and adjustments such as relay cropping. Farm diversification involves having many different on farm income generating activities and may include off-farm income sources. In uncertain environments, fodder availability fluctuates widely over time and space. Making use of such variable fodder requires tracking which involves the matching of a variable feed supply with animal numbers at a particular site (Scoones 1994).

Livestock can play important roles in income and consumption risk coping strategies (Dercon 1998 and Kinsey *et al.*, 1998). Explicit insurance contracts for handling risks typically do not exist in rural areas in developing countries because of problems of asymmetric information, adverse selection, and moral hazard (Binswanger *et al.*, 1987). This implies that risk allocation must be handled either privately or through implicit insurance schemes. Private management of risk can occur at two levels through income and consumption smoothing (Morduch 1995). In this way, farmers take steps to protect themselves against adverse income shocks before they occur.

Farmers can smooth the flow of income to the household through making conservative production choices, combining production enterprises that generate returns during different times of the year, and diversifying economic activities. Farmers do this in

practice using low yielding, but locally adapted, crop varieties, and by intercropping using several dispersed crop fields and pastures and combining crop and livestock enterprises (Morduch 1995 and Benin *et al.*, 2003). Farmers can smooth consumption by borrowing and saving; depleting and accumulating non-financial assets, including livestock; undertaking temporary migration; and relying on implicit or informal insurance arrangements. These mechanisms take force after shocks occur and help insulate consumption patterns from income fluctuations (Morduch 1995).

Some of the risk-management devices in income and consumption risk management strategies are, in general, endowment dependent and are conditioned by social phenomena (for example, property rights and kinship ties, population density, access to markets) (Carter 1997 and Benin *et al.*, 2003). Some of these effects are direct, while others are indirect. For example, to use diverse crop fields or pastures, a farmer must have access to particular kinds of land and this may necessitate negotiations with other members of the community. On the other hand population pressure leads to smaller farm sizes and often to more fragmented holdings, which may reduce farmers' ability or incentive to fallow. In sum, the way in which risk is handled will not only affect the farm enterprise combination but also the overall efficiency and development of the farm.

The bundle of property rights held by an individual bears significantly on their capacity to manage risk. In many parts of West Africa, "stranger" farmers originating from outside the community and women are restricted from planting or owning trees since doing so would confer greater land rights on them. Prevailing property rights and collective action institutions can affect farmers' ability to manage risks efficiently. For example plot scattering which takes advantage of micro-climate variations and reduces the possibilities

that a farmers' full range of crops will be lost to pest or weather problems, requires action institutionalized systems of land inheritance or active land markets so that farmers can optimally diversify their holdings through land swaps purchase or leases. The performance of land markets, in turn, depends on the presence of secure property rights. Plot scattering also requires that the government does not prohibit fragmentation, as often occurs based on the belief that land consolidation is necessarily more efficient (Knox *et al.*, 2002).

Farmers using common pool resources may respond to growing scarcity by engaging in cooperative action to rationalize use and improve their management. This could be through restraints on fodder harvesting or through schemes for controlling the timing and intensity of grazing. The extent of cooperation will, however, depend on the nature and degree of strategic uncertainty. Collective action would be more likely to take place in situations where strategic uncertainty is relatively small (Bromeley *et al.*, 1989). The specific action taken by individual farmers whether in cooperation or non-cooperation will have long-term effects on the common pool resources and livestock production.

Formal institutions (credit and extension), the private sector, and government policy can play a catalytic role in promoting sustainable intensification of crop- livestock systems. Conversely, partial intensification can be considered the end result of an institutional and policy failure. In Niger, the profitability of using highly variable improved inputs over time may create substantial financial risk for farmers (Timothy *et al.*, 2000).

## 2.2: Risks and risk management strategies in Kenya

Studies have been conducted to determine the types of risks faced by dairy farmers and about risk management strategies that they use (Nyangito 1992, Schaik 1995, Kaguongo *et al.*, 1997 and Nicholson *et al.*, 1999). However, studies to analyze the determinants of smallholder dairy farmer's adoption of various risk management strategies and their effects on profitability in smallholder dairy cattle herds are limited.

Using stochastic dominance criteria Nyangito (1992) ranked alternative East Coast Fever control methods. The criterion incorporates the decision makers risk attitude and ranks alternative choices by eliminating the inefficient ones. The alternative methods of ECF control ranked were in five scenarios reflecting different levels of Infection and Treatment Method (ITM) adoption. In consideration of risk attitude of the farmers, the dominance ranked the scenario, which reflected adoption of ITM accompanied by 75% reduction in acaricide use by farmers as the most preferable scenario.

In 1997, Kaguongo *et al.*, identified sources of risks in smallholder farms in Kiambu District, Kenya as mainly of two types: production or technical risk and market or price risk. Production or technical risk is a random variability inherent in a farm's production process. The sources of this risk in the area include among other factors, weather, diseases, pests and theft. Market risk or price risk occurs through purchased inputs and marketed outputs. The pattern of inputs prices in past years affects the farmers' choices and combinations of enterprises and their management practices.

Although farmers cited production risks as most critical, it is important to acknowledge the complementary that exist between production and market efficiency in stabilizing

farm household economy (Kaguongo *et al.*, 1997). Competitive prices, in the content of being “right” prices enhance the ability of a household economy to cope with production risks. Similarly efficient production helps buffer the households’ economy against instability occasioned by market risk. However, because of the diversity of agricultural conditions in Kenya, it is nearly impossible to determine a single “right price” for agricultural commodities (World Bank 1986).

Nicholson *et al.*, (1999) in a study that examined the factors associated with adoption of three dairy related technologies and practices in Coast Province found that loss of an animal due to disease was the most important of the risk mentioned by all adopting households, both before and after adoption. The assessment of the risks of losing an animal to disease, increased somewhat after adoption of the other risks mentioned by due households, “much more work for the household” and “changes to household routine” were close to disease risk in prevalence. The perceived likelihood of these risks decreased somewhat after adoption, however, the perceived risk of providing the grade/crossbred (G/C) animal with enough feed increased after adoption, but the perceived risk of not been able to sell milk decreased with experience. Other reasons not mentioned by all households include risk of theft, possibility of G/C being killed by wildlife and reduced ability of the household to move around.

Underfeeding prevents cattle in smallholdings from realizing a greater share of their genetic potential. The main technical constraints to adequate cattle feeding include poor quality and low quantity of available feeds and inadequate mineral supplementation (Muriuki *et al.*, 2003). For breeding, the technical constraints relate to long calving intervals that sometimes stretch up to 600 days (Omore *et al.*, 1999), although this is

sometimes a deliberate farmer strategy to reduce risks and prolong cash flow (Tanner *et al.*, 1998). Indeed, it is important to note that low cash input production strategies may be very appropriate for small farmers with limited credit sources and great aversion to risk (Kaguongo *et al.*, 1997).

Livestock can play important roles in income and consumption risk-coping strategies. As a coping strategy smallholder farmers invest in both livestock and crops as an insurance against failure of either (Kaguongo *et al.*, 1997). In Kenya, although there has been increased milk production, especially in smallholder sector, it has resulted mainly from an increased number of animals and use of land rather than from increases in individual cow-productivity (Muriuki *et al.*, 2003).

Most smallholder dairy farmers are averse to risk and adopt risk-reducing strategies involving elements as flexibility, liquidity diversification, and caution in adopting new techniques and for inputs having positive marginal risk, levels of input use which yield less than maximum expected net returns. While rational for the individual farmer, such behaviour results in output levels and product combinations that are inconsistent with those for which expected net returns are maximized (Kaguongo *et al.*, 1997).

Diversification onto higher value agricultural enterprises is a strategy pursued by many farmers in the central highlands of Kenya. This strategy requires good access to markets and the ability to produce a range of profitable higher value crops. This diversification and intensification within a smaller land area is a cushion against risky markets as well as farmers' recognition of farming as a business and not just a way of life. In areas where

farmers are not well linked into market opportunities, such as certain areas of Western Kenya, there has been little incentive to alter production patterns (Benin *et al.*, 2003).

Despite a high proportion of improved dairy cattle in smallholder farms, yields were low and this suggested that feeding could be the major constraint (Muriuki *et al.*, 2003). Part of the reason for our poor agricultural production is paucity of relevant information. Information, it is now acknowledged, is vital to production and business. Farmers need information to make right decisions on when, where and what to plant and how to market the produce and, maximize the returns. They also need to know the latest equipment and other farm implements in the market, which may heighten productivity (Benin *et al.*, 2003). The question of information is tied to research, and how, the findings are communicated (GoK 2005).

### **2.3: Economic analysis of milk production in Kenya**

A number of studies in the 1990s estimated the production costs and profitability of the smallholder Kenyan milk production. The estimated returns in smallholder dairy farming in Nyeri district located in Kenya highlands was 3.10 KES/ litre (Sellen *et al.*, 1990). In 14 districts covered by National Dairy Development Programme's (NDDP's) zero grazing projects the average cost of was 7.04 KES/ litre against producer prices of 5.20 KES/ litre (Waithaka *et al.*, 1992). In 21 districts under the zero grazing systems the average costs of production was 12.91 KES / litre (Maina *et al.* 1995).

In, estimated the mean annual milk yield per cow in NAD () and AD () households in Kiambu district, Kenya. The Non Agricultural Dependent (NAD) households had higher mean of annual milk yield per cow (2,916 kg) than that of Agricultural Dependent (AD)

(2,581 kg) with the latter earning more net income per cow milk per year (KES 18,945) than the former (KES 17363) (Kaguongo *et al.*, 1997). The NAD households had approximately one cow on average with less milk left for sale after home consumption. The AD households had approximately two cows on average with more milk left for sale after home consumption. Health and concentrate costs were 44% and 10% higher for NAD than AD group respectively. The sums cost of concentrates and health of NAD were 16% higher than for AD. This explained the 13% higher milk yield per cow in NAD. To maximize profit, the level of feeding concentrate would have to be increased by an average of 535 kg to 1601 kg per cow per year in Meru district, Kenya (Muriithi 1990). This would lead to milk yield of 4,773 kg per cow per year.

Longitudinal surveys conducted between October 1997 and December 1998 for Kiambu district, and between November 1998 and March 2000 for Nakuru and Nyandarua districts showed estimated returns of 4.10, 3.60 and 4.80 KES/ litre respectively (Staal *et al.*, 2003). However, simulated estimates of cost of production and revenues, April 2002 showed negative overall profits for all three study sites. The mean average price and earnings less the marketing costs from milk was 6.60 and 5.78 KES/ litre respectively in Kilifi district, Kenya (Echessah 1994).

#### **2.4: Characterization of livestock production systems**

In 1995, Sere and Steinfeld classified and characterized the world livestock production systems based on consideration of socio-economic and agro-ecological factors. Data limitations precluded full realization of the study observations. They proposed two basic types of systems namely solely livestock and mixed farming systems. In solely livestock system more than 90% dry matter of feed comes from pastures, rangelands, annual



forages and purchased feeds, and less than 10% of financial value of total farm production is from non livestock activities. In mixed farming system more than 10% dry matter of feed is from crop residues and by-products and more than 10% of financial value of total farm production is from non-livestock activities.

Several studies have been executed to characterize farming systems in Eastern Africa. In 1983, Sands made an in-depth study of the contributions of animals in two districts of Western Kenya (mean size 1.03 ha). Using a two dimensional model (household market and household farm) two major subsystems requiring labour and capital were characterized. In 1998, Odhiambo used partial analysis to classify farmers in Meru and Machakos district of Kenya in to different groups according to proximity to markets, the degree of market orientation and farm size.

Staal *et al.*, (1998 and 2001) and Waithaka *et al.*, (2002) characterized dairy systems in the Kenya by means of cluster analysis. In the characterization, a set of variable considered to reflect the primary measures of variability within that were chosen. In 1998 and 2001, Staal *et al.*, characterized dairy systems in Kiambu district located in Central highlands of Kenya in terms of level of intensification, household resources and access to markets and services. In 2002, Waithaka *et al.* characterized dairy systems in Western Kenya region terms of livestock management of the dairy system, management of the land, cropping system and level of access to input and output markets, and services.

Otieno *et al.*, (1999) cyclically monitored for six months a herd of 124 cattle from 11 farms in Teso district. Herd characteristics, reproductive performance, feeding management, productivity and herd health were used in characterization. Different

classes of animals were identified, 25% were bulls, of the milking cows, and 81% were over 6 years old and mostly in their second or third lactation indicating long calving intervals.

Williams (1993) used cluster and discriminant analysis to classify crop-livestock producers in three villages in western Niger into four recommendation domains using a combination of production and marketing variables and identified four recommendation domains. Fonteh, *et al.*, (2005) defined a peri-urban smallholder dairy farm in the Lake Crescent Region of Uganda as farm with five or less cows, located at the outskirts of town (between approximately 5 and 10 Km away from town) and limited land availability (< 2acres).

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### **3.0: MATERIALS AND METHODS**

#### **3.1: The study area**

The study was carried out in Kiambu district, Central Province of Kenya in a purposive multi stage design using Probability Proportion to Size (PPS) in a randomly selected sample of smallholder dairy farms. It borders Nairobi Province and Kajiado district to the south, Nakuru district to the west, Thika district to the east and Nyandarua district to the north (CBS 1996).

Kiambu district occupies 1323.9 square kilometers with a population density of 562 persons per square kilometer with 189,706 households (CBS 2001). It lies between latitudes  $0^{\circ} 75'$  and  $1^{\circ} 20'$  South of equator and longitudes  $30^{\circ} 54'$  and  $36^{\circ} 85'$  East with an altitude 1200-2550 metres above sea level. The rainfall is bimodal varying from 600-1200 mm per year depending on location and altitude. The annual mean temperature ranges from  $13.4^{\circ}\text{C}$  to  $21.9^{\circ}\text{C}$  in upper highlands and lowlands respectively. The district is intensively cultivated and cropped 1.4 – 1.7 times per year (Jaetzold and Schmidt 1983). Dairy farming in the district includes the intensive (zero grazing), semi-intensive and extensive grazing production systems. The subsistence food crops grown by the smallholders are maize, beans, potatoes and bananas. The main cash crops are coffee, tea, avocados, cut flowers, horticultural crops and pyrethrum (CBS 1996).

#### **3.2: Selection of study site**

Kiambu district was selected for the study for the following reasons.

- (i) The district is agro ecologically representative of Kenya's high agricultural potential areas. It has flexibility in enterprise mixes and thus reflects farmers'

reaction in response to various enterprise mixes, market opportunities and risk management opportunities.

- (ii) It's easily accessible for survey purposes and results feedback.

### **3.3: Sources of data**

The study used primary and secondary data. The primary data was collected through single visit personal interviews using a pre-tested questionnaire covering measures from farm resources to parameters reflecting farm functioning of households using production-to-consumption approach developed by ILRI (Rey *et al.*, 1993). The secondary data was collected from the Ministry of Livestock and Fisheries Development and Dairy Cooperative Societies monthly reports. The secondary data included milk yields and prices for calendar years 2002 – 2004.

Primary data was used to determine the significant factors affecting each risk management strategy. Secondary data aided in understanding the entire farm productivity and socio-economic framework in making calculations on farm sustainability.

### **3.4: Methods of data collection**

Before data collection, field extension workers with previous knowledge on questionnaire administration and enumeration were recruited and inducted. In addition two other enumerators were recruited and inducted. Thereafter the researcher and the enumerators pre-tested and revised the questionnaire using ten dairy farmers in lower midlands.

The survey document was divided into sections covering: farm location, characteristics of the household, sources of information used by the household to make decisions about

choice of enterprise combinations and management practices. The livestock inventory and production data was collected using “participatory herd history” method for calendar years 2002 – 2004. This information was used to develop econometric models to determine the significant factors affecting each risk management strategy.

Completed questionnaires were checked weekly before data entry. Where problems occurred such as omissions or contradictions, the respondents were revisited for clarifications. This was a continuous process between the researcher and enumerators in an attempt to improve the accuracy of subsequent interviews.

Data collection was conducted in December 2004 – February 2005. One to three farmers were interviewed per day using either local dialect or national language. The study relied heavily on farmer recall but recorded data and /or values were used where available. In some, if the farmer could not be reached or did not wish to participate in the study, another one in the locality was substituted.

### **3.5: Sample and sampling design**

Based on agro ecological zones as described by Jaetzold and Schmidt (1983), Kiambu district can be broadly divided into four zones: Upper midlands, Lower midlands, Lower highlands and Upper highlands. The purposive multi stage design using Probability Proportion to Size (PPS) sampling design was used. Locations with a higher population size (CBS 2001) had a proportionately higher sample size in the survey. Three agro ecological zones Upper midlands, Lower highlands and Lower midlands were purposively selected. In each agro-ecological zone (division), three locations were selected based on household density: highest, medium and lowest.

The number of households (Table 1) to be surveyed in each location was taken as a proportion of the number of households in the selected locations obtained from 1999 Population and Housing Census (CBS 2001). The sample size was obtained from estimating the number of observations potentially needed to distinguish between the three agro-ecological zones a difference of 30% in some of the important farm/household variables. Assuming a desired confidence interval of 95%, and using a coefficient of variation of 68%, which was the observed co-efficient of variation in Kiambu district dairy herd from previous studies (Kaguongo *et al.*, 1997) and a level of difference of 30%, a minimum sample size of 40 in each agro-ecological zone was calculated\*.

The chosen sample required then 14 observations in each location. However, in order to maintain proportionality, the number of observations in each location was adjusted to reflect the proportion of the number of households, resulting in sample sizes of 6 to 28 in each location. After maintaining a minimum of 10 observations in each location, the total sample size obtained was one hundred and thirty four households (Table 1). In order to capture as much local variations as possible, the sample in each stratum was spread across the 27 sub-locations among farms selected as randomly as possible.

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\*The calculation of sample size in each stratification class, to estimate a difference, is:

$$n = 2 \left[ \frac{zc}{d} \right]^2$$

Where:  $n$  = minimum sample size,  $z = 1.96$  for 95% confidence interval,  $c$  = Coefficient of Variation and  $d$  = Level of difference [Poate and Daplyn, 1993].

**Table 1: Number of households reported in the 1999 Population and Housing Census for the locations covered by the survey and the number of households in the survey by agro-ecological zone/division**

Agro-ecological zone/ Division	Locations	Populations 1999 census	Households 1999 census	Calculated Sample	Number sampled
Upper midlands/ Kiambaa division	Kiambaa (h)	39,548	10,235	19	19
	Kihara (m)	32,364	9,124	16	16
	Cianda (l)	11,850	3,547	7	10
	Total	83,762	22,996	42	45
Lower highlands/ Limuru division	Limuru (h)	37,102	9,492	28	28
	Ngecha (m)	10,860	2,626	8	10
	Rironi (l)	7,572	1,829	6	10
	Total	55,534	13,947	42	48
Lower midlands/ Ndeiya division	Ndeiya (h)	23,708	5,374	18	18
	Karai (l)	27,866	6,934	23	23
	Total	51,574	12,308	41	41
Grand total			49,251	125	134
Percentage (%)				0.25	0.27

Source: C.B.S. (2001). N.B.: h: highest density, m: medium density, l: lowest density

### 3.6: Data processing

Completed questionnaires were rechecked before data entry and where problems such as omissions, contradictions or doubtful answers were again noted, the respondents were revisited for further clarifications. The data was then processed and analyzed as per the objectives of the study.

### 3.7: Data analyses

The data from questionnaires was entered into Statistical Program for Social Scientists (SPSS) from SPSS Inc. and Microsoft Excel from Microsoft Corporation. Descriptive statistics were computed using the SPSS and Microsoft Excel software; it involved constructing frequency distributions, calculating means and standard deviations and cross-tabulations. Chi-square statistic was used to examine the impacts of risk management choice by the set of policy related variables. Since the criterion for grouping farms was based on agro-ecological zones, any significant difference between groups would imply that there is a difference between them. A two-tailed t-test was used to test statistical significance at  $p < 0.05$ .

Principal components analysis and cluster analysis were used to characterize the smallholder dairy production and marketing systems in the area to allow better targeting of future dairy research and development programmes. Principal components analysis is survey research in data reduction without omitting potentially important information (Mick 1990). The process generates new variables that consist of the sum of the products of the weightings and their scores along the original variables. Groups of variables used in the principal components analysis that might distinguish between clusters are selected *a priori*. For each theme a set of variables considered to reflect the primary measures of variability within that theme are chosen. Depending on the level of weighting, factors generated define new variables arbitrary. The variables identified are then used to cluster the household observations cluster analysis (Mick 1990).

Econometric logit models were used to analyze the determinants of small-scale dairy farmers' adoption of various risk management strategies. Logit models provide empirical

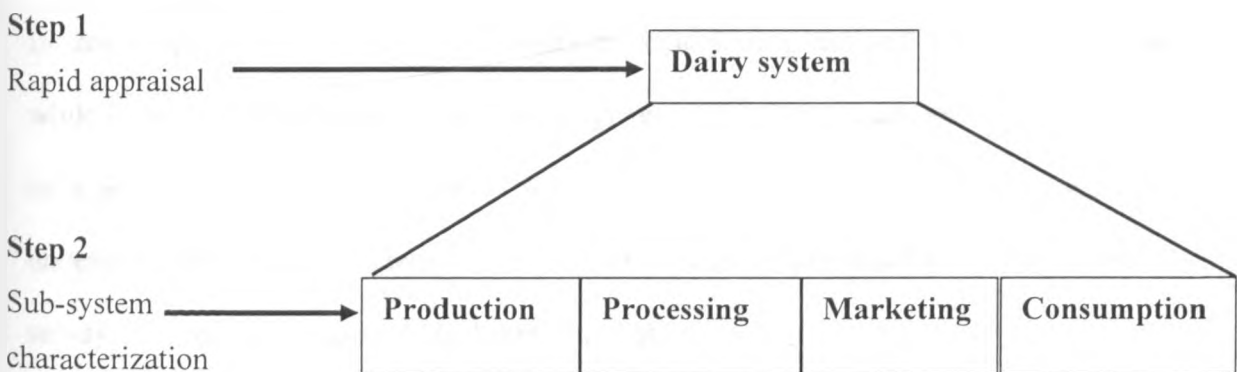


estimates of how changes in exogenous variables influence the probability of adoption of any technology. Logit models have a dependent variable bound between 0 and 1 and are convenient for dichotomous adoption variables (Nicholson *et al.*, 1999).

The milk price is just part of the economic that determines profitability. The economics of milk production was determined through farm profits formula (Bailey 2001) where farm profits equals to the “milk margin” time’s amount of milk produced less other costs. Milk margin equals milk price less feed costs KES/ kg of milk.

### 3.8: Conceptual framework

A review of conceptual framework (Figure 1) used in the study categorizes the process of research diagnosis and solution development in phases from constraint and opportunity identification, to seeking solution for dairy systems and finally to replications to comparable sites.



**Figure 1: A review of the conceptual framework of production-to-consumption approach used in study.**

In the framework, a dairy system incorporates all areas and production systems producing, and the marketing channels delivering dairy products to consumers including the policy environment. The study site is defined by a consumer centre with its dairy shed and processing and marketing actors and processors linked to them. In the conceptual framework, there are two phases designated steps 1 to 2.

Step 1: Appraisal of a given dairy system, often at a national (or sub-sector) level, to understand the main characteristics of production, processing, marketing and consumption. Information gathered is mostly qualitative, collected from key informants.

Step 2: More detailed characterization of the dairy system, including quantification of its components at the household level for production and consumption, and at the levels of individual processing and marketing units.

In this study, the consumer centre is any milk-marketing channel used by the farmer, while lower highlands, upper midlands and lower midlands represent the milk shed where milk is produced. This survey deals with the appraisal of smallholder dairy system to understand the main characteristics of production, consumption and marketing to enable sub-system characterization (Step 1 and 2) in figure 1.

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## **4.0: CHARACTERIZATION OF SMALLHOLDER DAIRY PRODUCTION SYSTEMS FOR LIVESTOCK IMPROVEMENT IN KENYA**

### **HIGHLANDS**

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### **ABSTRACT**

Characterization of smallholder dairy production systems in Kenya highlands is critical in understanding the constraints and opportunities that exist within the farming systems. It allows better targeting of dairy improvement research and development. The methodology used was based on a conceptual framework for dairy systems analysis developed by International Livestock Research Institute. Principal components analysis and cluster analysis were used to classify smallholder dairy farms in terms of risk management strategies, level of household resources, dairy intensification and access to services and markets. Four clusters of dairy systems were identified. Cluster 1, 2, 3 and 4 had 11.9%, 11.2%, 35.1% and 41.8% households respectively. Cluster 1 had no farmers in upper midlands and majority of farmers (56%) in lower highlands. Cluster 2 had majority of farmers (40%) in lower midlands. Cluster 3 had youngest farmers with smallest land sizes with majority of farmers (62%) in upper midlands. Cluster 4 had majority of farmers (50%) in lower highlands. Therefore, information obtained can be valuable for detailed analysis of

constraints and opportunities found in smallholder dairy systems and to design policies and strategies to support smallholder dairy development programmes in Kenya highlands under differing intensification one has to be aware of the challenges.

**Key words:** Smallholder dairy farming systems, characterization and Kenya highlands.

## INTRODUCTION

Developing appropriate interventions to assist smallholder dairy households, and identifying those which should be targeted requires a clear understanding of the dairy systems (Pearson, 2003). Dairy production systems are considered a subset of the farming systems (Wilson, 1994). Characterization is the grouping of farmers with similar practices and circumstances for whom a given recommendation would be broadly appropriate (Byerlee *et al.*, 1980).

Williams (1993) used cluster and discriminant analysis to classify crop-livestock producers in three villages in western Niger into four recommendation domains using a combination of production and marketing variables. Fonteh, *et al.*, (2005) defined a peri-urban smallholder dairy farm in the Lake Crescent Region of Uganda as farm with five or less cows, located at the outskirts of town (between approximately 5 and 10 Km away from town) and limited land availability (< 2acres).

Dairy production is the primary source of livelihood for over 600,000-smallholder farm families in Kenya (Omore *et al.*, 1999). Using principal components analysis and cluster analysis (Staal *et al.*, 1998 and 2001) characterized dairy systems supplying the Nairobi milk market into four recommendation domains based on level of dairy intensification, farm/household resources and access to services and markets. In Staal *et al.*, (1998), the four main domains of farmers distinguished were the informal resource poor, the cooperative resource poor, the elite and the specialists. In Staal *et al.*, (2001) the

informal resource poor, the intensive part time, the extensive landed and specialists farmers were distinguished.

Milk production systems vary widely with breeds of animals used, intensity of land and labour use and feeding systems in Kenya (Wakhungu, 2001 and Muriuki *et al.*, 2003). The main objective of this study was to characterize the smallholder dairy production systems in Kiambu district for livestock improvements based on constraints and opportunities identified.

## METHODOLOGY

The study used conceptual framework for dairy systems analysis of production-to-consumption approach developed by ILRI (Rey *et al.*, 1993). Data were collected from December 2004 to March 2005 through a survey questionnaire in Central Province located in Kenya highlands. Mburu *et al.* (2005a) presents a detailed description of the study area.

### Sampling procedure

Purposive multi stage design using Probability Proportion to Size (PPS) sampling design was used. Three agro-ecological zones: Upper midlands, Lower highlands and Lower midlands (Jaetzold *et al.*, 1983) were chosen purposively. Within the agro-ecological zones, eight research locations were selected based on household density: low, medium and high. Locations with a higher population size (CBS 2001) had a proportionately higher sample size in the survey. In order to capture as much local variations as possible, the sample in each zone was spread across the 27 sub-locations among farms selected as randomly as possible. In some, if the farmer could not be

reached or did not wish to participate in the study, another one in the locality was substituted.

The sample size was obtained from estimating the number of observations potentially needed to distinguish between the three agro-ecological zones by a difference of 30% in some of the important farm/household variables. Assuming a desired confidence interval of 95%, and using a coefficient of variation of 68%, which was the observed co-efficient of variation of households in Kiambu dairy herd from previous studies (Kaguongo *et al.*, 1997); a minimum sample size of 40 in each agro-ecological zone was calculated\*.

The chosen sample required then 14 observations in each location. However, in order to maintain proportionality, the number of observations in each location was adjusted to reflect the proportion of the number of households, resulting in sample sizes of 6 to 28 in each location. After maintaining a minimum of 10 observations in each location, the total sample size obtained was 134 households (or 0.27 % of the households in Kiambu district).

### Identification of principal components

In order to distinguish characteristic patterns of dairy activity existing among households in Kiambu district, a clustering method was applied to some of primary

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\* The calculation of sample size in each stratification class, to estimate a difference, was based on the equation:

$$n = 2 \left[ \frac{zc}{d} \right]^2$$

Where: n = minimum sample size, z = 1.96 for 95% confidence interval, c = Coefficient of Variation, d = Level of difference [Poate and Daplyn, 1993].



variables. The method uses principal component analysis followed by cluster analysis. Principal components analysis is used in survey research in data reduction without omitting potentially important information (Mick, 1990).

In principal components analysis, factors are extracted sequentially, such that the first accounts for the maximum common factor variance across all variables (i.e. more than any other factor that could be extracted). Thereafter, a second factor (reference factor) is then extracted which is at right angles to the first factor (i.e. orthogonal to it) such that the maximum amount of the common factor variance remains (Mick, 1990). In the process the apparently most important variation from a larger set of variables are identified and then used to cluster the household observations. Typically factors are extracted as long as the latent roots (e.g. Eigen values) are greater than one. If less than one, they can be alternatively chosen by reference to significant gaps between them. Thereafter, based on these rules, the chosen principal components are rotated then orthogonally to improve interpretability. Only loadings above .30 or below -0.30 should be considered as significant (Mick, 1990).

In the second step, farm/ households are then scored along the new vectors, and those created are used in standard cluster analysis. Since the variables were standardized in the analysis to have mean 0 and 1 variance, a correlation coefficient or weighting of 1, indicates strong correlation, 0 is neutral and -1 shows strong negative correlations. Therefore, negative means indicate levels lower than the overall sample mean.

### **Selection of variables used in principal component analysis**

The groups of variables used in the principle component analysis that might distinguish between clusters were selected *apriori*. The themes chosen were:

- *The level of intensification of the farm dairy system.*

- *The risk management strategy employed.*
- *The level of access to output markets and input services, and*
- *The farm/ household resources available.*

These four themes thus formed the conceptual framework used in the principal component analysis and cluster analysis. For each theme a set of variables considered to reflect the primary measures of variability within that theme were chosen. There were considerable variations between the themes (Appendix 1).

The principal components analyses were carried out on the four variables using the data from the 134 household observations. Finally, each of the 134 households was given a score along the new variables generated that consisted of the sum of the products of the weightings and their scores along the original variables. Anderson-Rubin method of estimating factor score coefficients that ensured orthogonality of the estimated factors was used. The scores produced had a mean of 0, a standard deviation of 1, and are uncorrelated (Mick, 1990). However, the recipients of cluster solutions should always be wary about the validity of the clusters, as cluster analysis is not based on stochastic foundations.

## **RESULTS**

### **Principal components analysis by level of access to services and markets**

Six principal components selected to indicate level of access to services and markets (Appendix 1) in the principal components analysis yielded two factors with an Eigen value greater than 1, which explained 63.4% of the variation in selected variables. Provision of extension services by cooperatives is a proxy for availability of cooperative services. Cooperative membership is a proxy for access to both input and output markets.

Depending on the level of weighting, factors 1 and 2 defined new variables arbitrary called COOPPART (Cooperative participation) and MKTDIST (Distance to market) respectively (Table 1).

### **Principal components analysis by level of risk management strategy used**

Five principal components selected as important measures of risk management strategies (Appendix 1) yielded two factors with an Eigen value greater than 1, which explained 65.7% of the variation in selected variables. Risk management strategies are important as they affect the level of returns (KES /kg) of milk produced (Mburu *et al.*, 2005b). Private management of risks can occur at two levels through income and consumption smoothing (Murdoch, 1995). Depending on the level of weighting, factors 1 and 2 defined new variables arbitrary called CONSMOOT (Consumption smoothing) and INCSMOOT (Income smoothing) respectively (Table 2).

### **Principal components analysis by level of household resources**

Four principal components selected as important measures of household resources (Appendix 1) yielded one factor with an Eigen value greater than 1, which explained 47% of the variation in selected variables. Income from off-farm employment is important to dairy intensification through their effects on increasing working capital. One factor is not rotated and depending on the level of weighting, factor 1 defined a new variable arbitrary called HHEADXS (Household head characteristics) (Table 3).

### **Principal components analysis by level of dairy intensification**

Five principal components selected as important measures of dairy intensification (Appendix 1) yielded two factors with an Eigen value greater than 1, which explained

69.3% of the variation in selected variables. Depending on the level of weighting, factors 1 and 2 defined new variables arbitrary called ONFARMFO (On-farm fodder production) and OFFARMFO (Off-farm fodder production) respectively (Table 4).

## DISCUSSIONS

Four clusters were identified using principal components analysis and cluster analysis (Table 5). Each cluster had unique constraints and opportunities, which helped define research priorities based on opportunities and constraints. Appropriate interventions should consider variations in all factors of production, and the relationships and patterns among the clusters.

Cluster 1 had 11.9% of the households (Table 5). The cluster recorded highest levels of risk management strategy through income smoothening, use of on-farm and off-farm produced fodder and lowest total farm income. It had high reliance on dairy cooperative as a source of information by households. It was composed of old farmers and the majority did not work off-farm. Upper midlands had no farmers in this cluster (Appendix 1) and majority of farmers (56%) in lower highlands. The cluster was characteristic of dairy farmers who relied on own produced fodder as they had largest parcels of land.

Cluster 2 consisted of 11.2% of households (Table 5) with majority of farmers (40%) in lower midlands. It was characterized by furthest distance to the nearest market centre and between various parcels of land (Appendix 1). These farmers did not rely on off-farm produced fodder

Cluster 3 contained 35.1% of households with majority of farmers (62%) in upper midlands (Table 5). Cluster 3 households marketed their milk through the informal market channels only and had lowest cooperative participation. In this cluster majority of

household heads worked off-farm and had lowest mean age and total farm area (Appendix 1). Households in this cluster managed risks through consumption smoothing and income smoothing.

Cluster 4 which contained 41.8% of households and majority of farmers (40%) in lower highlands (Table 5) characterized by high cooperative participation and lowest reliance on on-farm produced fodder and consumption smoothing as a risk management strategy. This cluster had least distance to nearest market centre and distance between farms and highest cooperative participation, which was characterized by lowest milk prices. Due to small farm sizes they had highest cost of purchased fodder per TRLU of dairy cattle (Appendix 1).

## CONCLUSIONS

The majority of farmers were in cluster 3 and 4. In cluster 4 interventions should be channeled through the cooperatives. Cooperatives should be encouraged to broaden their services and undertake most of the services previously provided by the government e.g. besides providing store merchandize services, artificial insemination and animal health services, should be able to provide technical services on crop husbandry and credit according to the needs of the members. However, the government should retain a regulatory role as envisaged in National Agriculture and Livestock Extension Programme (NALEP) to ensure dissemination of high quality extension messages. In cluster 3 off-farm incomes played an important role in income stabilization. Legal framework to regulate the operations of informal milk marketing channels should be formalized. Farmers should be encouraged to undertake additional activities such as horticulture and poultry which stabilize household incomes to enable them adopt dairy technologies

without exposing them to additional risk e.g. off-farm activities facilitate adoption of dairy technologies by the risk averse farmers.

### **ACKNOWLEDGEMENTS**

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**Table 1: Rotated correlation co-efficient factor pattern level of access to services and markets**

Description of variables	Component	
	Factor 1 COOPPART	Factor 2 MKTDIST
1. Price of milk (KES / kg)	-.843	-.0815
2. Distance to market (km)	.05448	.849
3. Milk marketing channel (1=cooperative and other informal channels, 0=informal channels only)	.919	.0757
4. Member of dairy cooperative (1= Yes, 0=No)	.888	.106
5. Dairy cooperative source of information (1=Yes, 0=No)	.511	-.443
6. Maximum distance between farms from farm of residence (km)	.08137	.497

Source: Estimated from the survey data collected in 2004/2005 in Kenya highlands by the authors.

**Table 2: Rotated correlation coefficient factor pattern level of risk management strategy**

Description of variables	Component	
	Factor 1 CONSMOOT	Factor 2 INCSMOOT
1. Leases land (1=Yes, 0=No)	.898	-.140
2. Number of farms cultivated	.917	.06856
3. Cost of home grown fodder (KES / kg)	-.0946	.710
4. Access to credit (=Yes, 0=No)	-.170	.686
5. Number of animals left per year	.251	.732

Source: Estimations from the survey data collected in 2004/2005 in Kenya highlands by the authors.

**Table 3: Un-rotated correlation co-efficient factor pattern of level of household resources**

Description of variables	Component
	Factor 1 HHEADXS
1. Household head age (years)	.817
2. Household head works off-farm (1=Yes, 0=No)	-.586
3. Total farm area under household care (acres)	-.535
4. Total household income from off-farm (KES / kg)	.764

Source: Estimations from the survey data collected in 2004/2005 in Kenya highlands by the authors.

**Table 4: Rotated correlation co-efficient factor pattern level of dairy intensification**

Description of variables	Component	
	Factor 1 ONFARMFO	Factor 2 OFFARMFO
1. Weight of concentrates per TRLU* of dairy cattle (kg/day)	.199	.833
2. Cost of purchased fodder per TRLU of dairy cattle (KES / kg)	-.442	.426
3. Total household farm size per TRLU of dairy cattle (acres)	.880	.07939
4. Acreage of napier planted per TRLU of dairy cattle (acres)	.867	.300
5. Cost of milk output /TRLU of dairy cattle (KES)	.101	.851

Source: Estimations from the survey data collected in 2004/2005 in Kenya highlands by the authors.

\*TRLU (Tropical Ruminant Livestock Unit): A standard unit by which livestock of different species are compared. It is defined as an animal with the equivalent of 250 kg live weight, e.g. camels- 1.0 TRLU, cattle- 0.7 TRLU (ILCA 1993).



**Table 5: The means for each variable within each final cluster, the frequency of households in each cluster and the significance levels (F)**

<b>Factors/ Clusters</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>F</b>	<b>Sig</b>
Consumption smoothing	.12375	-.14943	.3299	-.27224	3.465	.018
Income smoothing	1.44917	.00425	-.6186	.10406	27.994	.000
Total farm income	-1.1521	-.20073	.4853	-.02436	14.270	.000
Cooperative participation	.53850	.30334	-1.199	.77131	177.644	.000
Distance to market centre	-.33223	2.1652	-.1868	-.32821	64.932	.000
On-farm produced fodder	1.95432	.08685	-.1921	-.42037	52.490	.000
Off-farm produced fodder	.52937	-.36253	-.1155	.04279	2.475	.064
Frequency of households	16	15	47	56		
Percentage cases	11.9	11.2	35.1	41.8		
Upper midlands (%)	.000	33.3	61.7	19.6		
Lower highlands (%)	56.3	26.7	14.9	50.0		
Lower midlands (%)	43.7	40.0	23.4	30.4		

Source: Estimations from the survey data collected in 2004/2005 in Kenya highlands by the authors.

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**Appendix 1: Means of variables used in principal components analysis and cluster analysis classified according to cluster.**

<b>Description of variables</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<b>1. Level of intensification of the dairy system</b>				
i. Price of milk (KES /kg)	17.39	17.40	20.48	16.762
ii. Distance to market (km).	1.92	5.83	1.71	1.62
iii. Maximum distance between farms (km)	1.21	4.57	1.17	1.04
iv. Milk marketing channel (1=cooperative and other informal channels, 0=informal channels only)	.75	.80	.00	.928
v. Member of dairy cooperative (1= Yes, 0=No)	.88	.87	.13	.98
vi. Dairy cooperative source of information (1=Yes,0=No)	.69	.07	.13	.55
<b>2. Risk management strategies</b>				
i. Leases land (1=Yes, 0=No)	.25	.266	.404	.160
ii. Number of farms cultivated	2.00	1.45	1.91	1.45
iii. Cost of home grown fodder (KES / day)	22.75	9.18	5.08	6.72
iv. Access to credit (=Yes, 0=No)	.88	.53	.11	.70
v. Number of animals left per year	.94	.55	.52	.636
<b>3. Level of access to output markets and input services</b>				
i Household head age (years)	58.31	58.00	50.26	52.375
ii. Household head works off-farm (1=Yes, 0=No)	.063	.53	.68	.36
iii. Total farm area under household care (acres)	6.71	3.543	1.70	2.072
iv. Total household income from off-farm (KES /month)	1437.5	3966.6	6346.8	4018.7
<b>4. Farm/ household resources</b>				
i. Weight of concentrates per TRLU of dairy cattle (kg/day)	4.11	2.12	1.98	2.61
ii. Cost of purchased fodder per TRLU of dairy cattle (KES /day)	1.14	1.68	2.54	3.70
iii. Total household farm size per TRLU of dairy cattle (acres)	2.74	1.19	.95	.81
iv. Acreage of napier planted per TRLU of dairy cattle (acres)	1.13	.37	.34	.297
v. Cost of milk output per TRLU of dairy cattle (KES)	127.03	89.06	111.00	94.998

Source: Authors estimation from the survey data collected in 2004/2005 in Kenya highlands.

## **5.0: DETERMINANTS OF SMALL SCALE DAIRY FARMER'S ADOPTION OF RISK MANAGEMENT STRATEGIES IN KENYA HIGHLANDS**

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### **Abstract**

The study was carried out in one hundred and thirty four smallholder dairy farms in three agro-ecological zones in Central province located in Kenya highlands between December 2004 and March 2005. The main objective of the study was to analyze the determinants of smallholder dairy farmer's decisions to adopt various risk management strategies using econometric logit models. The logit models of risk management strategies revealed considerable differences across lower highlands, upper midlands and lower midlands in Kiambu district. The logit models of factors determining routine animal health services and veterinary services, changes in livestock numbers, use of purchased feed and fodder management practices were non-significant ( $p > 0.05$ ). However, logit model of milk marketing through cooperative channel was significant ( $p < 0.05$ ). Lower midlands, leased land, price of milk (KES /kg) and total farm acreage were negatively influenced ( $p < 0.05$ ) farmers' adoption of milk marketing through the cooperative channel. Lower highlands, hired permanent labour, number of cows milked, average milk production per cow (kg/ day), dairy cooperative as a source of animal production information, household head worked off-farm and availability of credit services had positively influence. The

study suggests the importance of cooperative channel in information dissemination and milk marketing. This has policy implications, as there is high dependence on dairy cooperatives as a production information source and milk-marketing channel.

## Introduction

Rural households in many parts of sub-Saharan Africa typically face considerable risks because of weather and price variability, crop and animal diseases and pest attacks <sup>1</sup>. Any factor that could lower revenue or increase expenses is a source of risk to the economic performance of the dairy business. Farmers' attitudes towards risk are quantitatively important determinants of their decision making, especially in less developed countries where risks are relatively larger, incomes lower, and risk spreading fewer <sup>2</sup>.

Econometric studies of peasants' risk attitudes are usually based on the observed gap between expected revenue and marginal costs <sup>3</sup>. In literature much normative analysis (with mathematical programming etc) has been done to show how farmers should behave under uncertainty <sup>4</sup>. Most empirical studies using econometric models often relate the adoption decision to households and technological characteristics. Numerous studies have found that constraints imposed by these factors have discouraged technology adoption <sup>5, 6</sup>. These factors influence the awareness, availability, costs, benefits and risks associated with the different livestock technologies and management practices <sup>7</sup>.

Understanding the factors affecting the farmers' adoption of risk management strategies is critical to success of development and implementation of policies and programmes in smallholder dairy industry. But surprisingly little work has been done to

examine the determinants of adoption of any risk management. This relative lack of information about farmer's risky environment and their relations to it means that there are few useful practical insights for policy makers and extension agents.

The specific objective of the study was to analyze the determinants of farmer's adoption of any certain risk management strategy. There were six types of risk management strategies investigated: fodder management practices, use of purchased feed, milk marketing channels, use of animal health services and changes in livestock numbers.

## **Materials and Methods**

### **Description of study site**

The study was carried out in Kiambu district, Central province located in Kenya highlands from December 2004 to March 2005. The Kenya highlands comprise areas with altitude 1200-2550 metres, annual mean temperatures of 13.4<sup>0</sup>C to 21.9<sup>0</sup>C. The rainfall is bimodal varying from 600-1200 mm per year depending on location and altitude. Fertile soils here have good potential for biomass production and intensively cultivated and food cropped 1.4-1.7 times per year <sup>8</sup>.

The district occupies 1323.9 km<sup>2</sup> with a population density of 562 persons per km<sup>2</sup> with 189,706 households <sup>9</sup>. Dairy cattle's farming in the district includes the intensive (zero grazing), semi-intensive and extensive grazing production systems. The subsistence food crops grown by the smallholders are maize, beans, potatoes and bananas. The main cash crops are coffee, tea, avocados, cut flowers, horticultural crops and pyrethrum <sup>10</sup>.



## **Data collection**

The study used conceptual framework for dairy systems analysis of production-to-consumption approach developed by ILRI <sup>11</sup>. Primary data were collected through personal interviews using a survey questionnaire covering measures from resources to parameters reflecting farm functioning from respondents with at least one dairy cow at the time of survey. All information referred to the situation of the day before the survey. Secondary data were collected from the ministry of Livestock and Fisheries Development and Limuru, Kiambaa, Gikambura and Nderi dairy farmers' cooperative societies. The data from questionnaires was entered into Statistical Program for Social Scientists (SPSS) from SPSS Inc.

## **Sampling procedure**

Purposive multi stage design using Probability Proportion to Size (PPS) sampling design was used. Three agro-ecological zones: Upper midlands, Lower highlands and Lower midlands were chosen purposively. Within the agro-ecological zones, eight research locations were selected based on household density: low, medium and high. Locations with a higher population size <sup>9</sup> had a proportionately higher sample size in the survey. In order to capture as much local variations as possible, the sample in each zone was spread across the 27 sub-locations among farms selected as randomly as possible. In some, if the farmer could not be reached or did not wish to participate in the study, another one in the locality was substituted.

The sample size was obtained from estimating the number of observations potentially needed to distinguish between the three agro-ecological zones by a difference of 30% in some of the important farm/household variables. Assuming a desired confidence interval of 95%, and using a coefficient of variation of 68%, which was the

observed co-efficient of variation of households in Kiambu dairy herd from previous studies <sup>12</sup>; a minimum sample size of 40 in each agro-ecological zone was calculated <sup>13\*</sup>.

The chosen sample required then 14 observations in each location. However, in order to maintain proportionality, the number of observations in each location was adjusted to reflect the proportion of the number of households, resulting in sample sizes of 6 to 28 in each location. After maintaining a minimum of 10 observations in each location, the total sample size obtained was 134 households (or 0.27 % of the households in Kiambu district).

### **Logit and probit models**

Most empirical studies using econometric models often relate the adoption decision to household and technological characteristics. Numerous studies have found that constraints imposed by these factors have discouraged technology adoption <sup>5, 6</sup>. The two models used in adoption studies are the logit and probit models both of which have a dependent variable bound between 0 and 1 and are convenient for dichotomous adoption variables <sup>6</sup>. Probit model is particularly well suited to experimental data while logit model is for observational data <sup>14</sup>.

Logit models provide empirical estimates of how changes in exogenous variables influence the probability of adoption of any technology. The results of the logit model

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\* The calculation of sample size in each stratification class, to estimate a difference, was based on the equation:

$$n = 2 \left[ \frac{zc}{d} \right]^2$$

Where: n = minimum sample size, z = 1.96 for 95% confidence interval, c = Coefficient of Variation, d = Level of difference <sup>13</sup>.

estimates were reported as the marginal effects of a change in the exogenous variables, that is, the change in the probability of choice due to a one-unit change in the exogenous variable. In the case of dummy variables (i.e. 0 or 1) such as households buying fodder, the marginal effect is the difference in probability due to belonging to one group rather than the other (e.g. households buying fodder versus households not buying fodder). For continuous variables such as the age of household head, the marginal effect is the change in probability due to an increase in one year in age. The impact of other categorical and continuous variables can be interpreted analogously. The magnitude, statistical significance and the signs (i.e. positive or negative influence on probability of choice of risk management strategy) of the marginal effects are typically of most interest in evaluating the factors influencing the determinants of any risk management strategy.

## **Results**

The dependent variables index the adoption of any risk management strategy. The variable takes the value of 1 if the farmer currently uses or had adopted the strategy and 0, otherwise. Table 1 shows the arithmetic means of dependent variables used to estimate the logit models for determinants of adoption of any risk management strategy.

The number of households using various risk management strategies varied across the three survey sites respectively (Table 1). Lower highlands had the highest proportion of households that bought fodder, decreased use of purchased concentrates when animal dry, animals left farm, marketed milk through the cooperatives, used dairy meal and milling by-products and animal health services. Lower midlands was lowest in use of milling by-products, vaccination and marketing of milk through neighbours while upper midlands had the highest proportion of households marketing their milk through informal channels.

Table 2 shows the names, units of measurements or values and arithmetic means of explanatory variables used to estimate the logit models for determinants of choice of any risk management strategy. The explanatory variables related to farmers resources (human and physical), institutional (extension and credit) and location.

Lower highlands had the highest number of cows milked and average milk production per cow per day of 1.8 and 10.3 litres respectively while in lower midlands the number of households leasing land was the lowest but had the highest land area of 3.45 acres (Tables 2).

### **Logit regression results**

The logit model was estimated using SPSS 10.0 Window<sup>14</sup>. Only results of those regressions in which the overall logit model is statistically at the 5% level of significance are presented. The results of logit model of milk marketing through the cooperatives are given in Table 3. The econometric model was fitted with 25 variables. The table shows the contribution of each variable towards milk marketing through the cooperative channel.

Eleven explanatory variables were significant ( $p < 0.05$ ) in explaining of adoption of milk marketing through the cooperative channel. Upper midlands, leased land, average milk price (KES/ kg) and total farm acreage negatively influenced the adoption of milk marketing through the cooperative channel while the rest had positive influence. Only significant factors ( $p < 0.05$ ) affecting adoption of milk marketing through the cooperative channels levels are discussed.

## **Discussions**

### **Location variables**

Upper midlands and lower highlands were significant (Table 3) and negatively and positively influenced the adoption of milk marketing through the cooperative channel respectively. This suggested that households in upper midlands were less likely to market their milk through the cooperatives than those in other areas. Due to its close proximity to Nairobi city, hawking was expected to play an important role in upper midlands <sup>15</sup>. In lower highlands, households were more likely to market their milk through the cooperatives than those in upper midlands probably due to lack of alternative competitive informal markets.

### **Land size**

Total farm acreage influenced negatively the adoption of milk marketing through the cooperative channel (Table 3). This suggested that the probability of milk marketing through the cooperatives decreased as the total land size increased, although the effect of an additional acre of land was relatively small (1.9%). This indicated that the amount of land did not markedly constraint farmers wishing to market their milk through the cooperatives. Large land sizes characterized old dairy farmers who had no alternative sources of income and thus the need for daily cash from milk sales through itinerant traders.

### **Household head off-farm employment**

The probability of milk marketing through the cooperatives increased if household head worked off-farm (Table 3). This was a reflection of employed farmers'

increased interest in cooperative market. Off-farm employment affected milk marketing through the cooperatives as the owner being employed off-farm had extra cash thus no need for daily cash. These would contribute to farmers selling milk where there is lump sum payment. Off-farm income increased cash available for dairy investment leading to more milk production <sup>12</sup>. The only available market for such milk was the cooperative outlet. Household heads that were mostly men tended to seek employment off-farm rather than work on-farm because of proximity to urban areas <sup>15</sup>.

### **Hired permanent labour**

Hired permanent labour influenced positively adoption of milk marketing through the cooperative channel (Table 3). This suggested that the probability of milk marketing through the cooperatives increased if household hired permanent labour. Hiring of permanent labour maybe an indication of the farmer having a large herd and would contribute to farmers selling milk where there is lump sum payment. Perhaps permanent labour employment led to more efficient utilization of resources and hence more milk production. The cooperative market remained the only reliable channel for excess milk.

Labour was required in all aspects of dairy production including planting, weeding and fertilization of fodder plots, fetching and feeding of cows, milking and delivering milk to the points of sale. In dairy production, both family and direct employees were involved. Employment generation through small-scale dairy marketing and processing depending on enterprise creates 2.0-0.3 direct and indirect jobs for every 100 litres of milk traded <sup>16</sup>. Most households practiced three or four different labor arrangements with permanent and/or casual laborers and family labour. It is not adult men, but equally women and children who participated in the dairy production process

and decision-making. The importance of family labour in any farm enterprise cannot be understated <sup>15</sup>.

### **Leasing of land**

Leasing of land influenced negatively the adoption of milk marketing through the cooperative channel (Table 3). This suggested that the probability of milk marketing through the cooperatives decreased with household leasing land. In Kiambu district 27% of households leased land (Table 2). Households (26.9%) were involved in multiple tenure arrangements as they cultivated land belonging to someone else. Such parcels of land were not likely to be near the homestead requiring daily cash to travel to, fetch fodder from or carry out other agronomic practices like weeding. On these farms different crops either in pure stands or various combinations are grown. This was a risk management strategy, which leads to land fragmentation <sup>17</sup>.

### **Numbers of cows milked and milk yield per cow per day (kilogramme)**

The number of cows milked and average milk production per cow positively influenced the adoption of milk marketing through the cooperative channel marginally at 3.1% and 2.9% respectively (Table 3). This suggested that the probability of milk marketing through the cooperatives increased marginally with increase in the number of cows milked and milk yield per cow per day. Farmers selling milk to cooperatives are likely to have excess milk. The additional milk produced required a reliable market outlet that was only offered by the cooperatives.

### **Price of milk (KES /kg)**

There was a negative relationship between the average milk price (KES /kg) and adoption of milk marketing through the cooperative channel (Table 3). This suggested that the probability of milk marketing through the cooperatives increased with decrease in milk price. Perhaps unlike other channels that imposed milk delivery quotas during times of milk glut, cooperatives did not but offered lower prices. All cooperatives had coolers that especially catered for the evening milk.

Cooperatives had the capacity to take all milk delivered and dispose it but at lower prices. This degree of volatility made it difficult to plan cash flow needs for the dairy enterprise. Dairy farmers need to budget each month for feed purchases, hired labour, and veterinary and artificial insemination expenses and any other expense. Cash flow problems occur when milk prices fall below expected levels <sup>19</sup>.

### **Credit availability**

Adoption of milk marketing through the cooperative channel was influenced positively by credit availability (Table 3) suggesting that the probability of milk marketing through the cooperatives increased with ease of credit availability. It can be assumed that farmers who wanted credit from cooperatives were more likely to sell their milk there to improve their credit rating. Apart from milk marketing, provision of credit was the other core function of dairy cooperatives. Credit offered included artificial insemination and veterinary clinical services and provision of store merchandize like concentrates and milling by-products to ensure constant milk production to off set the loan to its active members without substantive security. Therefore, most of credit offered was for operational costs. However, credit for dairy development and other uses like



school fees were offered. Unlike banks that required security in form of title deeds, vehicle logbooks or quoted public company shares, cooperatives decided milk delivery track record as security.

### **Dairy cooperative as a source of extension information**

Dairy cooperative was an important source of information. It influenced positively the adoption of milk marketing through the cooperative channel (Table 3) though marginal (5.4%). This suggested that the probability of milk marketing through the cooperatives increased if dairy cooperative was the source of extension information. It can be assumed that farmers who required extension services from cooperatives were more likely to sell their milk there. Therefore, farmers marketing their milk through the cooperative were likely to be more knowledgeable than other farmers using other market channels.

The information passed by cooperatives varied. It was either pure agricultural which can be used without acquisition of a specific physical technology or agricultural formation inherently tied to new physical inventions <sup>5</sup> to pass this information, the cooperatives relied on collaboration with ministries of livestock and fisheries development, agriculture and cooperative development as well as research stations, non-governmental organizations like Heifer International, Land-O-Lakes and feed and drug manufacturers.

The dairy cooperatives thus were not only marketing channels, but also a significant source of other market information for farmers particularly with regard to concentrates, veterinary clinical drugs, and artificial insemination services and forage seeds <sup>12, 15</sup>. Consequently, they determined in many ways what breed of cattle should

farmers keep and type of concentrates to feed in response to market demand. Cooperatives can thus unwittingly contribute to the failure or success of dairy industry. It was not unusual for farmers to feed one or two concentrates which are recommended as best by the cooperatives<sup>17, 18</sup>.

### **Extension agent as a source of extension information**

Other policy related intervention like extension agent as a source of extension information had relatively small negative and insignificant effects on adoption of milk marketing through the cooperative channel in Kiambu district. This implied that extension was playing a negative role in cooperatives marketing. Extension agents usually urged farmers to sell their milk to the highest bidder. Given the low milk prices offered by cooperatives, it was not one of their preferred options.

Others like membership to agricultural farmers' group had marginal positive influence (4.1%). Membership to farmers associations and saving societies has helped farmers to participate in trainings and agricultural events, which have formed a major source of knowledge and skills applied in the farm<sup>20</sup>.

### **Conclusions**

Programmes to improve and strengthen cooperatives can contribute to the development of dairy industry and substantially contribute to alleviating poverty. These will lead to profits generation which act as incentives in adoption of improved risk management strategies. Farmers selling milk to cooperatives will have excess milk; require extension services and credit from cooperatives. Access to credit through the cooperatives must be improved to enable farmers intensify milk production practices.

There is an increased role of cooperatives in information dissemination in a liberalized milk market. Therefore, the farmer cooperatives movement needs to be revamped and their mandate expanded and enhanced to provide access to inputs, provision of reliable breeding services and improved market access. Extension service should be closely linked to cooperatives to reach many deserving smallholder farmers. Farmers should therefore, seek or be provided with information on improved risk management strategies from the cooperatives.

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**Table 1: Arithmetic means of dependent variables used in econometric model of determinants of choice of risk any management strategy**

Dependent variables	Mean value of variable			
	Lower highlands	Upper midlands	Lower midlands	Overall
<b>Fodder management practices</b>				
• Buys fodder (1* = Yes, 0* = No)	.71	.67	.66	.68
• Conserve fodder (1* = Yes, 0* = No)	.33	.22	.54	.38
<b>Use of purchased feed</b>				
• Decrease use of purchased concentrates when animal dry (1* = Yes, 0* = No)	.88	.60	.80	.76
• Use dairy meal (1* = Yes, 0* = No)	.81	.60	.71	.71
• Use milling by-products (1* = Yes, 0* = No)	.69	.62	.37	.58
<b>Milk marketing channels</b>				
• Cooperative market (1* = Yes, 0* = No)	.83	.31	.53	.7
• Hawkers/ hotels market (1* = Yes, 0* = No)	.42	.53	.46	.47
• Neighbors market (1* = Yes, 0* = No)	.17	.24	.12	.18
<b>Changes in livestock numbers</b>				
• Animals joined farm (1* = Yes, 0* = No)	.33	.24	.41	.33
• Animals left farm (1* = Yes, 0* = No)	.94	.82	.80	.86
<b>Animal health practices</b>				
• Deworms (1* = Yes, 0* = No)	.85	.60	.61	.69
• Vaccinates (1* = Yes, 0* = No)	.75	.62	.34	.58
• Ticks control (1* = Yes, 0* = No)	.54	.16	.44	.36
• Breeding method (1* = Artificial insemination, 0* = Others)	1.0	.71	.95	.89

\* The variable takes the value of 1 if the farmer currently uses or had adopted the strategy and 0, otherwise.

**Table 2: Explanatory variables used in econometric logit model of determinants of choice of some risk management strategy**

Explanatory variables	Mean value of variable			
	Lower highlands	Upper midlands	Lower midlands	Lower highlands
<b>Location variables</b>				
• Upper midlands (*1 = Upper midlands, 0* = Others)	0	1	0	0
• Lower highlands (*1 = Lower highlands, 0* = Others)	1	0	0	0
<b>Characteristics of household head and farm (human and physical)</b>				
• Household age (Years)	54.1	53.8	50.6	53.0
• Education (1* = Post primary, 0* = Primary)	.42	.31	.56	.42
• Household head works off-farm (1* = Yes, 0* = No)	.33	.64	.39	.45
• Number of persons in household	5.3	5.3	4.7	5.1
• Lease land (1* = Yes, 0* = No)	.29	.42	.07	.27
• Number of farms cultivated	1.8	2.0	1.2	1.7
• Total farm acreage (acres)	3.0	1.6	3.45	2.7
• Area under forage (%)	44.0	40.2	35.8	40.21
• Hires permanent labour (1* = Yes, 0* = No)	.94	.56	.95	.25
• Distance from farm to nearest market (Km)	2.0	2.1	2.45	2.2
• Number of cows milked	1.8	1.4	1.5	1.7
• Average price of milk (KES /kg)	17.50	19.30	17.85	18.20
• Average milk production (kg/day/cow)	10.3	7.7	8.3	8.8
<b>Institutional factors and information sources (institutional)</b>				
• Extension services available through GoK, cooperatives, NGOs and other private providers (1* = Yes, 0* = No)	.86	.98	.84	.89
• Extension agent (1* = Yes, 0* = No)	.69	.83	.80	.78
• Credit services available (1* = Yes, 0* = No)	.60	.27	.61	.49
• Member of farmers' group member (1* = Yes, 0* = No)	.35	.27	.24	.35
• Fellow farmers (1* = Yes, 0* = No)	.33	.27	.29	.28
• Sales agents (1* = Yes, 0* = No)	.38	.07	.49	.31
• Farmer tours (1* = Yes, 0* = No)	.21	.20	.10	.17
• Agricultural shows (1* = Yes, 0* = No)	.44	.13	.29	.29
• Radio programmes (1* = Yes, 0* = No)	.35	.27	.34	.32
• Dairy cooperatives information (* = Yes, 0* = No)	.83	.10	.49	.48

\* The variable takes the value of 1 if the farmer currently uses or had adopted the strategy and 0, otherwise.

**Table 3: Logit model regression co-efficient and standard errors (S.E) of determinants of milk marketing through cooperative channel**

<u>Explanatory variables</u>	<u>B ± S.E.</u>
Intercept	3.82271±3.23554
Upper midlands	-.20036±.51135**
Lower highlands	1.50335±.36786**
Household head age (YEARS)	-.00413±.01096
Household education level	-.16382±.26983
Household head worked off-farm	.03941±.32208*
Number of persons in farm	-.02072±.06950
Hired permanent labour	.18113±.37243**
Distance to nearest market (Km)	.08342±.07873
Number of farms	.32725±.22642
Total farm acreage (acres)	-.01984±.06764*
Area under forage (%)	.00896±.00722
Leased land	-.42241±.42960*
Number of cows milked	.03120±.18942**
Average milk production (kg/cow)	.02980±.04428**
Average milk price (KES /kg)	-.58789±.17773**
Extension services available	.18658±.58128
Credit services available	.44490±.31519**
Extension agent	-.18653±.44012
Member of farmers' group	.04120±.32588
Agriculture shows	-.42056±.37690
Fellow farmers	-.05709±.29840
Farmers' tours	.29175±.40066
Sales agent	.17157±.30397
Dairy cooperatives information	.05466±.34194**
Radio programmes	.11918±.28564

\*\*Correlation significant at the 0.01, \* Correlation significant at the 0.05 level.

Chi Square=403.130, DF=107, P=.000

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**6.0: AN ECONOMIC ANALYSIS OF SMALLHOLDER DAIRY CATTLE  
ENTERPRISES IN DIFFERENT AGRO-ECOLOGICAL ZONES IN KENYA  
HIGHLANDS.**

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**Abstract**

The study was carried out in one hundred and thirty four smallholder dairy farms in three agro-ecological zones in Central province located in Kenya highlands between December 2004 and March 2005. The survey showed that dairy enterprise was the most important income generating farming activity in 96.7% of households in Kenya highlands and probably the most single important farming activity in the region. Majority of Kenyans' small-scale farmers own most of their fixed costs and can therefore make decisions based on profits only. The computation of production costs and revenues (from the milk sold, consumed by households and calves) were based on the dairy enterprise only. The results showed that the costs of production and unit profits (KES / kg) of milk produced were 16.90 and 6.30, 19.05 and 2.30, and 18.05 and 3.45 in upper midlands, lower highlands and lower midlands respectively. Though some farms had negative gross margins (0.09%), on average revenues significantly exceeded costs and the dairy enterprise returned of profit. These estimates are important for policy makers and development

planners when making decisions related to availability and cost of any risk management strategy in dairy enterprise.

## **Introduction**

In Kenya the livestock sub-sector accounts for about 42% of Kenya's agricultural domestic product <sup>1</sup>. Dairy production is the primary source of livelihood for over 600,000-smallholder farm families <sup>2</sup>. Longitudinal surveys conducted between October 1997 and December 1998 for Kiambu district, and between November 1998 and March 2000 for Nakuru and Nyandarua districts showed estimated returns of KES 4.10, 3.60 and 4.80 per litre respectively <sup>3</sup>.

The cost of milk production and its profitability is affected by factors that determine farm-gate milk prices across the rural areas of Kenya <sup>3, 4</sup>. As a result there has been continued interest from the public and from policy makers in the profitability and competitiveness of Kenya dairy production.

The low productivity, therefore, in general presents a problem to individual farms in terms of the levels of yields per cow and for the country with regard to efficiency of utilization of scarce agricultural resources <sup>3, 5</sup>. Therefore, an understanding of the performance of smallholder farmers is an important pre-requisite for policy formulations aimed at improving productivity.

## **Materials and Methods**

### **Description of study site**

Detailed descriptions of the study area and survey methodology were presented in detail <sup>5</sup>. The information collected was used to calculate the costs of production and unit profit (KES / kg) of milk produced in the dairy enterprise.

## **Economics of milk production**

Gross output constitutes of those products which become routinely available through the production process. Such products can be marketed through a diversified and well established marketing system e.g. milk and breeding stock. However, in Kiambu district, the livestock production systems deal with products which do not have a clear defined market value e.g. calves reared at different intensity levels to be used for breeding later on, and to a certain extent heifers<sup>3</sup> and hence not included in analysis. The value of purchased animals and manure were also not included. However, the value of manure on crops or planted forages represented additional revenue to the farm as an intermediate input.

Due to lack of reliable data and ease of computation, forage- crop residues gathered on-farm and off-farm were not included in the analysis, although associated costs (labour and transport costs) were included. Fixed costs were ignored since were unrelated to higher levels of milk production and do not affect the optimal combination of the variable inputs<sup>7</sup>. Majority of Kenyans' small-scale farmers own most of their fixed costs and can therefore make decisions based on gross margins only.

The computation of production costs and revenues (from the milk sold, consumed by households and calves) were based on the dairy enterprise only. Quantities of inputs used and outputs obtained whether sold and/or consumed by household were calculated as an arithmetic mean of sampled households. In this analysis, no attempts were made to quantify the non-marketed benefits to the smallholder dairy enterprise.

Total variable costs incorporated costs of all purchased inputs, veterinary and artificial insemination services, permanent and family labour and off-farm and on-farm produced fodder. The value of milk used by household and calves is included under costs but also under revenues since it is a product of the farm. Revenues included the total

value of milk produced in the farm i.e. sales of milk and the value of milk consumed on the farm and calves, and sales of cattle, whether culled cows, males or heifers. Unit profits are mean revenues less mean costs.

Land under dairy enterprise was valued at the full reported rental rate. This was reflected in the analysis as the cost of own produced forage. Family labour was valued at 80% of the reported lowest monthly wage of permanent labour. It was a reflection of the assumption that the opportunity cost of family labour was below the wage rate simply because off-farm employment was not always readily available to family farm members.

The receipts of milk produced were calculated using the farm profit (KES /kg) formula characterized as follows:

$$\text{Farm profit} = [\text{Milk margin (KES /kg)} \times \text{Milk volume (kg)}] - \text{Other variable costs} \quad (1)$$

Where:

$$\text{Milk margin} = [\text{Milk price (KES /kg)} - \text{Feed cost (KES /kg)}] \quad (2)$$

The milk margin was important as it represented Kenya shillings left over to pay for other costs of production and realize a profit. The primary objective of any farmer was to protect the milk margin on a portion of the milk he or she sold<sup>7</sup>. Therefore, milk price and amount of milk produced were just part of economic equation that determined dairy enterprise profitability. The other variable costs (KES /kg) of milk produced were labour, veterinary and artificial insemination services among others. These were the risk management strategies that affected the unit profit margin.

After computing the milk margin for the three survey sites, a one-way analysis of variance was used to find out whether the costs of production, profits and price (KES / kg) were significantly different at (P < 0.05) 2-tailed test for the three regions. The hypotheses to be tested were:

$$H_0: G1 = G2 = G3 \quad (3)$$

$$H_1: G1 \neq G2 \neq G3 \quad (4)$$

*Where G1 = Costs of production/ profits/ price in lower highlands*

*G2 = Costs of production/ profits/ price in Lower midlands*

*G3 = Costs of production/ profits/ price in upper midlands*

## Results

### Characteristics of surveyed farms

The characteristics of surveyed farms varied across the agro-ecological zones (Table 1). In lower highlands and upper midlands the land area devoted to crops and fodder were equal. Lower midlands had lowest proportion of land area devoted to fodder production, number of parcels of farms, household head age and population density but highest total farm acreage. Lower highlands had the highest household head age; proportion land area devoted to fodder, cows in milk and milk output per cow per day but lowest distance to market and average price (KES / kg). Upper midlands had the highest milk price (KES /kg), number of farms and population density but lowest in all others except household head age, distance to market and percentage area devoted to forage production which were moderate (Table 1).

### Estimated cost of risk management strategies

The costs of various risk management strategies per unit of milk produced varied across the agro-ecological zones (Table 2). During the time of the survey, calves and households consumed 6% and 18.5% respectively of total milk output in Kiambu district (Table 1). Lower highlands had the lowest costs of labour and purchased fodder but highest costs of water and concentrates and milling by-products (KES / kg) of milk

produced. Lower midlands had highest costs of purchased and homegrown fodder, and veterinary services (KES / kg) of milk produced. Upper midlands had highest costs of labour only and lowest in costs of water (Table 2). The cost of mineral salts was included in cost of concentrates and milling by-products.

The average price received, cost of production and profit (KES /kg) from milk shown in Table 3. The cost of milk production (KES / kg) was 12.7% and 6.8% higher in lower highlands and lower midlands respectively than in upper midlands. It was highest (19.05) and lowest (16.90) in lower highlands and upper midlands respectively. The sales prices (KES / kg) were highest in upper midlands at 19.30 and lowest in lower highlands at 17.50 (Table 3).

Dairy enterprise was the most important income generating farming activity in 96% of households in Kiambu district and probably the most single important farming activity in the region (Table 1). Though some farms had negative gross margins (0.09%), on average revenues significantly exceeded costs and the dairy enterprise returned a profit. The profits ranged from KES / kg 2.30, 6.30 and 3.45 in lower highlands, upper midlands and lower midlands respectively (Table 3).

Nevertheless, a one-way analysis of variance showed that there were no significant differences ( $P > 0.05$ ) between the arithmetic means of the costs of production for the three agro-ecological zones. The differences between arithmetic means of returns of milk in KES /kg were significant ( $P < 0.05$ ) between lower highlands and upper midlands while that of price of milk (KES / kg) were significant ( $P < 0.05$ ) between upper midlands and lower highlands and lower midlands (Appendix 1).

## Discussions

### Sales price

Factors that determine farm-gate milk prices affect the cost of milk production and its profitability across the rural areas of Kenya. Market prices are reflective of a number of supply, demand and policy factors<sup>3, 4</sup>. Following the liberalization of dairy processing and marketing in 1992, a number of significant developments have taken place in milk marketing. The cooperatives societies and other middlemen began to pay higher prices to farmers<sup>4</sup>. This was attributed to the increased competition from raw milk vendors and direct sales.

The sales price was highest in upper midlands at 19.30 KES /kg (Table 3) due to lowest proportion of farmers who marketed their milk through the cooperative channel<sup>6</sup>. Lower highlands had the lowest sales price of 17.50 KES / kg and highest proportion of farmers who marketed their milk through the cooperative channel<sup>6</sup>. Lower midlands had a sales price of KES / kg 17.85. In all agro-ecological zones the informal markets offered higher prices the cooperatives (Table 3).

In Kiambu district, the cooperatives experience shortage and surplus of milk in the dry (January- April) and wet (rest of the year) seasons respectively<sup>4</sup>. During the dry season the cost of production is high as farmer rely more on off-farm purchased fodders and concentrates while the sales price remains fairly constant<sup>3</sup>. This acts as a disincentive to increased milk output.

Physical access to markets has a direct bearing on farmers' production costs and the price they receive. As transport costs increase with increasing distance, the price farmers must pay for their material input rises while the prices they receive for their marketed commodities falls, implying deteriorating terms of trade. The high impact of poor roads alone on milk price is reflected in studies that estimate a price reduction of 47



cents per litre per kilometer of bad road <sup>4</sup>. This means that the returns per unit of land declines and so does the incentive to produce for market.

### **Cost of production**

Measuring the cost of production is important if farmers want to know whether or not they are making profit. While the sale price of milk is known, it is often difficult to measure milk production costs and profits <sup>7</sup>. The production costs should not only include the costs of transport, labour and marketing, plus reasonable profit, but also costs of risks posed to buyers and sellers of non-delivery and non payment <sup>3</sup>.

The costs of production were highest (19.05 KES / kg) and lowest (16.90 KES / kg) in lower highlands and upper midlands respectively (Table 3). Use of commercial dairy supplement is common, but for a variety of reasons, the amounts fed varied from 2.30, 2.90 and 4.70 kg /cow /day in lower midlands, upper midlands and lower highlands respectively (Table 1) and appear unrelated to the level of milk production. This contradicts agricultural policies that advocate intensification of production, which requires external inputs and services in Kenya highlands to increase animal output and productivity <sup>8</sup>.

Utilization and cost of concentrates and milling by-products affected the cost of milk production (KES /kg). Lower highlands had the highest cost of production (Table 3) due high costs and amount of concentrates and milling by-products of KES /kg 8.50 and 4.70 kg/ cow/ day respectively (Tables 1 and 2). Lower midlands had the highest cost of concentrates and milling by-products of KES 17.65 per kg (Table 1). However, the cost of production was KES /kg 18.05 due to low amounts concentrates and milling by-products used of 2.90 kg /cow /day (Table 1).

In upper midlands, the low cost of production was attributed to low labour and water expenses. Only 6.7% employed labour on permanent basis. None of the farms bought water and costs incurred were that of labour for fetching it from nearby streams and rivers and shallow wells. In contrast all and 80% of farms in lower highlands and lower highlands respectively bought water for use by dairy enterprise from water projects scattered all over.

### **Farm profit**

The primary objective of any farmer is to protect the milk margin on a portion of the milk he sells. Therefore, milk price and amount of milk produced are just part of economic equation that determines profitability.

There were significant differences between returns in lower highlands and upper midlands. The high returns in upper midlands were attributed to low cost of production and milk prices offered by informal milk marketing channels and low labour and water expenses. The returns were highest and lowest in upper midlands and lower highlands at 6.30 and 2.30 KES /kg respectively with lower midlands at 3.45 KES /kg. The low returns in lower highlands were due to low milk prices offered by dairy cooperatives and high costs of production of 17.50 and 19.05 KES /kg respectively. In Kiambu district, the returns were KES /kg 3.95.

A study carried out in 1998 using partial budget analysis reported returns of 3.40 KES / kg <sup>6</sup>. In the same study simulated estimates of cost of production and revenues, April 2002, in Kiambu, Nakuru and Nyandarua districts showed negative overall profits.

The use of larger breeds' e.g. Friesian and Aryshire in favour of smaller breeds e.g. Jerseys and Guernsey have been discouraged because the former have higher

nutritional demands<sup>9</sup> and have performed poorly in terms of adaptive traits, milk yield and production efficiency<sup>5, 10</sup>. In addition, small sized dairy breeds like Jersey and Guernsey and their crossbreds form the superior alternative to the Friesian and Ayrshire in the Kenyan smallholdings with regard to age at first calving<sup>5</sup>.

The value of manure used on crops as an immediate input, planted forage and functions of livestock as security against risks represented an additional revenue to the farm. Studies in Kenya highlands have estimated that the value of manure may be some 30% of the value of milk sold<sup>11</sup>.

### Conclusions

Farmers in upper midlands were making much more profit from milk than those in lower highlands due to higher milk prices. These showed that cooperatives were not competitive in milk pricing and lower highlands farmers should utilize the other available milk marketing channels itinerant traders. This is the practice in milk marketing in a country like India. However, in absence of legal structures to govern the informal marketing channels like hawking farmers should continue marketing their milk through the cooperatives. Hence, policies to improve the operational and pricing efficiencies of dairy cooperatives would have a self-accelerating effect on productivity.

Dairy farmers require capacity building in agri-business principles and practice. To reduce the cost of production efforts to encourage and promote feeding of good quality fodder of Kikuyu grass or napier mixed legumes such as *Lucerne*, *Desmodium* and clover with care taken to avoid bloating.

They were no significant differences ( $p > 0.05$ ) in the cost of production between the three agro-ecological zones, an indication that the pattern of differences associated with greater intensification did not hold in the three survey sites. In addition alternative

uses of manure could be investigated especially in the production of biogas as fuel for the household. An analysis forage- crop residues gathered on-farm and off-farm should be carried out.

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**Table 1: Characteristics of the farms: arithmetic mean household values of some descriptive parameters**

<b>Parameters</b>	<b>Lower highlands</b>	<b>Upper midlands</b>	<b>Lower midlands</b>	<b>Overall</b>
Number of households	48	45	41	134
Population density (persons sq. km)	967.2	1798.8	240.6	1002.5
Household head age (years)	54.1	53.8	50.6	53.0
Distance to market center (km)	2	2.1	2.5	2.2
Number of parcels of farms	1.8	2.0	1.2	1.7
Total farm acreage (acres)	3.0	1.7	3.5	2.7
Percentage area under fodder	44.0	40.2	35.8	40.2
Total acreage under fodder (acres)	1.3	.64	1.2	1.1
Total acreage under crops (acres)	1.25	.64	1.9	1.2
Number of cows in milked	1.8	1.4	1.7	1.6
Milk output (cow/ day/kg)	10.3	7.7	8.3	8.8
Milk sold (kg/day)	15.7	9.2	9.6	11.6
Household milk consumption (kg/ day)	2.4	1.7	2.2	2.1
Calves milk consumption (kg/ day)	3.9	2.7	4.0	3.5
Average price (KES /kg)	17.50	19.30	17.85	18.20
Concentrates and milling by-products (kg/ cow/day)	4.70	2.30	2.90	3.36
Concentrates and by-products (KES /kg)	15.20	12.40	17.65	15.00
Concentrates and by-products (Kg/kg of milk/day)	.65	.43	.41	.50
Informal price (KES /kg)	20.00	19.60	20.30	20.05
Cooperative price (KES /kg)	17.0	17.10	16.35	16.80
Most important farm enterprise (%)	90	100	100	96.7

Source: Estimated from survey data collected in 2004/2005 in Kenya highlands by the authors.

**Table 2: Comparison of arithmetic mean values of costs of various risk management strategies per unit of milk produced in the three agro-ecological zones**

<b>Risk management strategy cost (KES /kg /day)</b>	<b>Lower highlands</b>	<b>Upper midlands</b>	<b>Lower midlands</b>	<b>Overall</b>
Cost labour (hired and family)	4.30 (22.6)	5.40 (31.8)	5.20 (28.8)	4.95 (27.4)
Cost of home grown fodder	.65 (3.4)	.55 (3.6)	1.10 (6.1)	.75 (4.2)
Cost of veterinary services	.55 (3.0)	.40 (2.4)	.65 (3.6)	.55 (3.1)
Cost of water	.80 (4.5)	.10 (.6)	.70 (3.9)	.55 (3.1)
Cost of purchased fodder	.45 (2.4)	.55 (3.6)	.80 (4.4)	.60 (3.3)
Cost of A. I services & bull services	.25 (1.3)	.30 (1.8)	.25 (1.4)	.25 (1.4)
Cost of concentrates & by-products	8.50 (44.0)	5.40 (32.0)	5.60 (31.0)	6.60 (36.7)
Cost of milking jelly	.15 (1.0)	.20 (1.2)	.20 (1.1)	.15 (.8)
Cost of milk of calves and household	3.40 (17.8)	3.90 (23.0)	3.55 (19.7)	3.60 (20.0)

Source: Estimated from survey data collected in 2004/2005 in Kenya highlands by the authors.

N. B: Number in parenthesis is percentage contribution to cost of production.

**Table 3: Average price received, cost of production and profit (KES / kg) from milk in the three agro-ecological zones**

<b>KES / kg</b>	<b>Lower highlands</b>	<b>Upper midlands</b>	<b>Lower midlands</b>	<b>Overall</b>
Sale price	17.50	19.30	17.85	18.20
Cost of production	19.05	16.90	18.05	18.00
Revenue from sale of milk and animals	21.35	23.20	21.50	21.95
Profit from sales of milk and animals	2.30	6.30	3.45	3.95
Profit from milk	1.85	5.05	2.75	3.15
Profit from sales of animals	0.45	1.25	.70	0.80

Source: Estimated from survey data collected in 2004/2005 in Kenya highlands by the authors.

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**Appendix 1: One way analysis of total cost of production returns and price of milk (KES / kg between Lower highlands, Upper midlands and Lower midlands.**

LSD

Dependent Variable	(I) Agro-ecological zone	(J) Agro-ecological zone	Mean Difference	Std.	Sig.	95% Confidence Interval	
			(I-J)	Error		Lower Bound	Upper Bound
Cost of production (KES / kg)	Lower highlands	Upper midlands	3.1560	1.8540	.091	-.5116	6.8237
		Lower midlands	1.4052	1.9001	.461	-2.3536	5.1641
	Upper midlands	Lower highlands	-3.1560	1.8540	.091	-6.8237	.5116
		Lower midlands	-1.7508	1.9291	.366	-5.5669	2.0653
	Lower midlands	Lower highlands	-1.4052	1.9001	.461	-5.1641	2.3536
		Upper midlands	1.7508	1.9291	.366	-2.0653	5.5669
Returns (KES / kg)	Lower highlands	Upper midlands*	-4.9874	1.9426	.011	-8.8303	-1.1445
		Lower midlands	-1.7641	1.9909	.377	-5.7026	2.1744
	Upper midlands	Lower highlands*	4.9874	1.9426	.011	1.1445	8.8303
		Lower midlands	3.2233	2.0212	.113	-.7752	7.2219
	Lower midlands	Lower highlands	1.7641	1.9909	.377	-2.1744	5.7026
		Upper midlands	-3.2233	2.0212	.113	-7.2219	.7752
Price of milk (KES / kg)	Lower highlands	Upper midlands*	-1.8314	.4413	.000	-2.7045	-.9583
		Lower midlands	-.3588	.4523	.429	-1.2536	.5360
	Upper midlands	Lower highlands*	1.8314	.4413	.000	.9583	2.7045
		Lower midlands*	1.4725	.4592	.002	.5641	2.3810
	Lower midlands	Lower highlands	.3588	.4523	.429	-.5360	1.2536
		Upper midlands*	-1.4725	.4592	.002	-2.3810	-.5641

\* The mean difference is significant at the .05 level.

## 7.0: GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

### 7.1: General discussion

To characterize smallholder dairy production systems across different sites in Kiambu district, identify constraints and opportunities to improve profitability by optimizing resource use based on key determinants to make decisions on choice of appropriate risk management data was collected through households' survey. The findings of the survey provided background information for identifying promising interventions for farmers to reduce the cost of production and increase the returns (KES / kg) of milk produced

Using principal components analysis and cluster analysis, four clusters were identified (Chapter 4). Each cluster had unique constraints and opportunities, which help define research priorities based on opportunities and constraints. The diversity in clusters considered suggests that different prescriptions will be needed to improve productivity. The majority of farmers were in cluster 3 and 4. In cluster 3 off-farm incomes played an important role in income stabilization. In cluster 4 interventions should be channeled through the cooperatives.

Econometric logit models were used to analyze the determinants of small-scale dairy farmers' adoption of various risk management strategies (Chapter 5). Logit models of changes in livestock numbers, use of purchased concentrate feeds and forage management practices, routine animal health and veterinary services were non-significant ( $p > 0.05$ ). However, logit model of milk marketing through cooperative channel was significant ( $p < 0.05$ ). Eleven explanatory variables were significant ( $p < 0.05$ ) in

explaining smallholder farmers' adoption of milk marketing through the cooperative channel. Lower midlands, leased land, price of milk (KES /kg) and total farm acreage negatively influenced farmers' adoption of milk marketing through the cooperative channel. Lower highlands, hired permanent labour, number of cows milked, average milk production per cow (kg/ day), dairy cooperative as a source of animal production information, household head worked off-farm and availability of credit services had positive influence.

The economic analysis of smallholder dairy enterprises in Kiambu district showed that the cost of production and unit profit were 16.90 and 6.30, 19.05 and 2.30, and 18.05 and 3.45 KES /kg of milk produced in upper midlands, lower highlands and lower midlands respectively (Chapter 6). The farm profit formula was used. The milk margin was important as it represented Kenya shillings left over to pay for other costs of production and realize a profit. The differences between the arithmetic means of the costs of production for the three agro-ecological zones were not significant ( $p < 0.05$ ). However, the differences between the arithmetic means of returns (KES / kg) of milk between lower highlands and upper midlands were significant ( $p < 0.05$ ).

## **7.2: Conclusions**

Farmers in upper midlands were making much more profit from milk than those in lower highlands due to higher milk prices. Cooperatives were not competitive in milk pricing and lower highlands farmers should utilize the other available milk marketing channels like itinerant traders. However, there was an increased role of cooperatives in information dissemination and milk marketing in a liberalized milk market. Hence, policies to

improve the operational and pricing efficiencies of dairy cooperatives would have a self accelerating effect on productivity.

Access to credit must be improved to enable farmers intensify milk production practices. The government should guarantee loans for dairy processing plants; assist dairy cooperatives to process milk into value added products such as butter, cheese, yoghurt, maziwa mala, milk powder for export and skimmed milk for production. Value addition to milk will improve profit margins only by broadening the market range for milk produced and generate more profit. In addition alternative uses of manure could be investigated especially in the production of biogas as fuel for the household.

Farmers are still unable to use improved inputs such as feed supplements, because they lack access to them and of the high variable costs of these inputs in relation to producer prices. This makes the profitability of using such inputs highly variable over time and may create substantial financial risk for the farmers.

### **7.3: Recommendations**

Appropriate interventions should consider variations in all factors of production, and the relationships and patterns among the clusters. Their implementation depends upon identification of interventions for development. This in turn depends upon practical knowledge of all farm enterprises to facilitate most sustainable and profitable decision making.

Programmes to improve and strengthen cooperatives can contribute to the development of dairy industry and substantially contribute to alleviating poverty. Cooperatives should be encouraged to broaden their services and undertake most of the services previously provided by the government e.g. besides providing store merchandize services, artificial insemination and animal health services, should be able to provide technical services on crop husbandry and credit according to the needs of the members. In addition the dairy cooperative(s) should process milk into more high value products such as butter, cheese, and yoghurt and maziwa mala as the way forward.

Extension service should be undertaken through cooperatives to reach many deserving smallholder farmers. Farmers should therefore, seek or be provided with information on improved risk management strategies from the cooperatives. In addition, risks can be reduced and production increased by exploiting diversity of such farming systems as well as introducing elements that can create additional opportunities.

Dairy farmers require capacity building in agri-business principles and practice. To reduce the cost of production efforts to encourage and promote feeding of good quality fodder of Kikuyu grass or napier mixed legumes such as *Lucerne*, *Desmodium* and clover with care taken to avoid bloating. This is the practice in dairy production systems in most countries e.g. South Africa, Australia, Brazil and New Zealand etc. Farmers should be encouraged to undertake additional activities such as horticulture and poultry which stabilize household incomes to enable them adopt dairy technologies without exposing them to additional risk e.g. off-farm activities facilitate adoption of dairy technologies by the risk averse farmers.

Legal framework to regulate the operations of informal milk marketing channels by licensing traders conditionally should be formalized. Farmers should be encouraged to undertake additional activities which stabilize household incomes to enable them adopt dairy technologies without exposing them to additional risk e.g. off-farm activities facilitate adoption of dairy technologies by the risk oversee farmers.

Measures to reduce the unit cost of production and marketing will increase the profitability of these systems and ease the risk pressure on farmers. To reduce the cost of production efforts to encourage and promote feeding of good quality fodder of Kikuyu grass or napier mixed legumes such as *Lucerne*, *Desmodium* and clover with care taken to avoid bloating. At the same time, research to boost the yields of crops and livestock should be encouraged. This research should be geared toward producing a diversified range of technical options to suit the needs of farmers with different resource endowments, management skills and ability to bear risk.

The data were for a small sample of households that may or may not be representative of Kenya highlands. There is a need for future work using a regionally panel data to better explore the observed patterns of increased role of cooperatives in milk marketing and information dissemination in a liberalized dairy industry.