DAIRY SYSTEMS CHARACTERISATION OF THE GREATER NAIROBI MILK SHED

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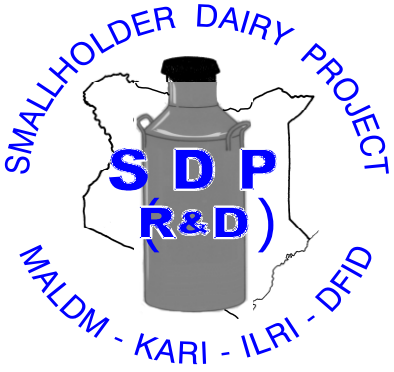

SDP Research Report

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Executive Summary

Background

An important first step in addressing the research and development needs of smallholder dairy farmers in Kenya is to accurately diagnose the existing and future constraints and opportunities facing them. These may occur at a number of levels: the dairy animals themselves, agro-ecology of the area, farm practices, household resources, level and type of services available, infrastructure, and other policy or macro-environment factors. To carry out this broad and multi-level diagnosis, a stratified random survey of households was conducted in what may be termed the Greater Nairobi milk shed, the target area for the Smallholder Dairy (R&D) Project's first phase. This study falls within the characterisation phase of the conceptual framework for dairy system research developed by ILRI (Rey et al, 1993).

The broad goals of the survey were to a) describe the current structure of dairy production and practices of dairy farmers in Central Kenya, b) assess current and future constraints and opportunities facing them, and c) identify those types of dairy producers that should be targeted by the SDP project, given the focus on assisting the most resource poor.

The conceptual framework used for stratifying the survey was based on the principle that the main determinants of dairy system development lie along two independent axes: a) agro-climatic potential and b) market access. Using existing maps of agro-ecological zones and road infrastructure, the Central Kenya area was differentiated into regions of high, medium and low market access, and high and medium agro-climatic potential. Eight districts were then selected that represented the diversity in potential for dairy development.

An SDP team comprised of collaborators from MoA, KARI, and ILRI conducted the survey in March-April 1998 among 1390 households chosen in a stratified random sample from the eight districts. Household were selected randomly without regard to whether they were farms or kept cattle. This systematic characterisation survey followed the form developed during the pilot characterisation survey in Kiambu District in 1996 (Staal et al 1997). It also applies to the Kenya setting some of the new methods available through linking GIS- (Geographical Information System) and farm-based analysis. To accomplish this, all surveyed household were geo-referenced using GPS (Global Positioning System) units.

Survey results

Of the 1,390 households that were randomly surveyed, 1,015 (74%) owned agricultural land and of these, 73% had dairy cattle. This underlines the fact that dairy is a prevalent enterprise among rural households over a wide area of central Kenya. The mean age of the household head was 47 years and the majority (70-85%) had primary or secondary level education. The average household size was 5.7 persons, including usually 2 adults in the age group 23 to 65 years.

There was great variation in types of cash crops grown from one district to another and even within districts, reflecting mainly differences in agro-climatic potential. Dairy farming is nevertheless a consistent feature across the area suggesting that it can be integrated with a variety of other crops and farming systems. Napier grass has been widely adopted as a fodder crop across and it is only in Narok district that napier growing was not practised. This is clearly associated with the greater land availability in that area and the consequent lower demand for intensive technologies such as planted fodder.

The results also emphasise the important role of dairying in generating employment in rural areas. In total, 60% of the households keeping dairy animals employed some type of casual or long-term labour. Within the household, analysis of labour allocation suggests that adult family males contribute 36% of the labour required by dairy activities, followed by 24% contributed by family females. This appears to contradict results from other studies that showed that females contributed the largest proportion of labour to dairy.

Cattle genotype differed according to the system of keeping dairy cattle in the manner expected, with more exotic genotypes in more intensive stall-feeding systems and local animals in the grazing areas. The predominant dairy breeds were Friesian (42%), Ayrshire (18%), Guernsey (12%) and Jersey (3%). The rest, representing local and other Bos indicus (Zebu, etc) accounted for 25% of the total number of animals. Herds were composed of mostly adult cows (44%) which together with heifers and female calves accounted for nearly two thirds of the animals in farm herds, while bulls comprised only 7% overall. However herd composition differs greatly across districts depending on level of intensification and orientation towards marketed milk production, with more males kept in areas with great land sizes such as in Narok.

Production practises were analysed both at the time of the survey and ten years previously, based on farmer recall. Overall the main production systems were semi-zero grazing for 38% of farms, zero grazing for 37% and grazing for 25% of farms mostly in Narok. Only in Nyandarua district did the study find evidence of improved pastures such as Rhodes and rye grasses. In other grazing-based farms in Narok and Machakos, natural pasture was used. The highest proportion of zero grazing farms was found in Maragua where 90% of farms relied solely on stall-feeding. The survey showed that there have been significant changes in feeding strategies compared to ten years ago (approximately 1988). Some farms in traditional grazing areas such as Machakos, Njoro, and Molo were found to have shifted towards stall-feeding. This is clearly related to shrinking land sizes and the consequent need for intensification of production. Further, farmers reported more dependence on Napier and crop residues now compared to use of roadside grass previously, such as in Machakos where 33% of dairy farms reported the introduction of Napier in the last ten years. A similar trend towards intensification was found in the changing patterns of crops.

The results of performance found in the survey are perhaps typical of smallholder mixed (crop-livestock) systems. The mean age at first calving was 32 months, calving interval and lactation length 519 days while the mean

milk yield was 5.9 litres/cow per day (for dairy cattle but lower for indigenous cattle).

An potential important constraint facing smallholder dairy producers may be decline in services due to the withdrawal of most of government support. In the case of artificial insemination (AI) for example, only 30% of the households reported its availability from the cooperatives and 25% reported its availability from private practitioners. For the majority of households, this service was simply not available. Overall, over 71% of the sampled households used bulls for breeding. As a result, lack of selective breeding may pose a long-term constraint to continued productivity increases if reduced use of AI leads to a degradation of the herd genotype.

In spite of known constraints to funding of public services, 80% and 85% of dairy farmers reported that government extension and veterinary services were available and 60% of farms reported using them. Private veterinary services were also available to 80% of farms, of which nearly 60% reported using them. Some 15% of farms reported that private extension services were also available.

In keeping with results of other studies, the survey found that most of the milk marketed by the farmers passed through informal channels and was not processed. The single largest market is sales to neighbouring households, which comprised the main outlet for 42% of the respondents. Of the others 22% sold to traders, 12% to co-operative societies and self-help groups and only 12% to processors (KCC and private processors). The remaining 11% sold to hotels and shops. Poor market access may be a considerable constraint to profitable dairy farming in some milk surplus areas. However the results suggest that in most areas local demand is strong enough to take up much of the milk. The market liberalisation of 1992 has apparently increased the market options for small farmers but has also introduced uncertainty and new risks. But it should be noted that sale of milk is not the sole farmer objective. Home consumption of milk is an important production aim and 37% of dairy households reported selling no milk. On average dairy producing households reported consuming some 2 litres per day.

Finally cluster analysis was conducted on the survey data to differentiate the surveyed dairy farms into characteristic types. A statistical method was used that focused on categorizing the farms according to several main themes: 1) the level of intensity of dairy production, 2) the level of household resources, and 3) access to markets and services. Based on this analysis, 4 main farm types were identified. The most important group, comprising 51% of the farms surveyed, are the Informal Resource Poor farms, which have the smallest land holdings, the largest proportion of female-headed households (25%), rely mainly on informal markets, and have poor access to markets and services. Other important groups are the Extensive Landed dairy farms and the Part-time or Peri-Urban dairy farmers, each of which make up 19% of farms. These have better access to resources and markets ether through having greater land holdings or by being located closer to urban centres. The last group identified was the Specialized Dairy farmer group, characterized by the high use of purchased feed and fodder inputs. Given the project goal of working towards the interests of the most resource poor, and also given their

predominant position in rural dairy production, the Informal Resource Poor farms are clearly the main targets for SDP research and development efforts.

Conclusions

Important implications from the findings can be drawn in four key areas: a) intensification of smallholder systems; b) constraints to dairy productivity; c) access to services; and, d) identification of target groups.

The results point clearly to the rapid intensification of smallholder dairy production that is occurring in the central part of Kenya apparently as a result mainly of shrinking land holdings. Over the last ten years farms have shifted increasingly to the use of stall-feeding and to planting of fodder, and now rely less on natural fodder. Also clear, however, are the wide differences in levels of intensification across the area depending on agro-climate and market access. The main implication is that while improved technologies for sustained intensification are needed, they cannot be applied uniformly. Blanket recommendations for intensive production strategies should be avoided. A difficult challenge may be to assist the appropriate intensification of farms in those outlying areas where many of the resource poor farmers are found, which do not have high agro-ecological potential, yet which need to improve productivity due to shrinking land holdings.

Constraints to dairy productivity continue to centre around inadequate and seasonal feed resources. Solutions to these problems will have to keep in mind the limitations to opportunities for intensification outlined above. For example the use of planted grass fodders for stall-feeding may be limited in extensive areas where labour rather than land is the limiting constraint. Threats to productivity over the long term may be posed by the constraint to breeding. AI services continue to be used by only a relatively small proportion of farmers and the long-term trends in herd genotype are unclear. Private veterinary services of indeterminate quality are now available to most farms across the area. Perhaps surprisingly, most farms report continued contact with government extension services. Few co-operatives offer breeding or vet services. The status of access to services is thus mixed with apparently successful private sector entry into vet services, but less success in the private provision of AI services. However, these services are used mostly by the more privileged or advanced dairy farmers.

The cluster analysis shows that about half the dairy farms in central Kenya remain resource-poor with small land holdings and are located far from formal market services and urban areas. Improving the sustained productivity and profitability of this large majority group of farms and households will be key to success in rural development, poverty reduction and environmental protection in the region.

1. Introduction

It has been estimated that smallholder dairy farmers produce over half of total milk production in Kenya and 80% of the total marketed milk (Peeler and Omore, 1997). Milk production systems vary widely in the breeds of animals used, intensity of land and labour use, and feeding systems. The 1992 milk market liberalisation gave impetus for the increased off-take of milk, by improving opportunities for dairy co-operatives and private entrepreneurs to market dairy products. As a result, changes are apparent in production and marketing in the greater Nairobi milk-shed. Yet little is known about these patterns of change and the effects of various determinants on them.

A collaborative study by KARI/MOA/ILRI was undertaken to characterise the Nairobi milk-shed, with a view to identifying constraints and opportunities in dairy. The study was conducted in Central, Eastern and Central Rift Valley Provinces of Kenya. These are areas that represent a wide range of levels of dairy productivity potential and market access within the Nairobi milk-shed.

Prospective study sites were grouped according to production potential and market access into High-High, High-Medium, High-Low, Medium-High, Medium-Medium and Medium-Low. Sub-locations to be sampled were selected randomly from pre-selected Divisions in each District, on the basis of the land-use systems (as classified by Jaetzold and Schmidt, 1983) namely Sheep-Dairy, Tea-Dairy, Coffee-Dairy, Horticulture-Dairy, Wheat-Dairy and Urban. The number of households to be surveyed in each Sub-location was taken as a proportion of the number of households obtained from 1989 census figures (C.B.S, 1994). The total required sample of 1401 households was obtained from estimating the number of observations potentially needed to distinguish between the land-use systems.

By surveying randomly-selected households within areas stratified by land use zones, and by applying a combination of GIS-based spatial analysis techniques and statistical methods, this study provided detailed system and farm-level analysis across a wide range of farm and livestock sub-systems within the Nairobi milk-shed. Ministry of Agriculture MOA frontline staff supervised by MOA Divisional and District staff and the KARI and ILRI researchers conducted the surveys, between March and April 1998

This systematic characterisation describes the wide variability of production strategies present in a relatively small area, and the growing competitiveness of less-intensive dairy production. It also applies in the Kenya setting some of the new methods available through linking GIS-based and farm-based analysis.

The results showed that a majority of rural households are agricultural and many practice dairy farming. There is an increasing shift towards intensification of dairying through growing of fodder crops with “cut-and-carry” feeding systems and keeping of improved dairy breeds on the ever decreasing land available for agriculture. The importance of direct milk sales

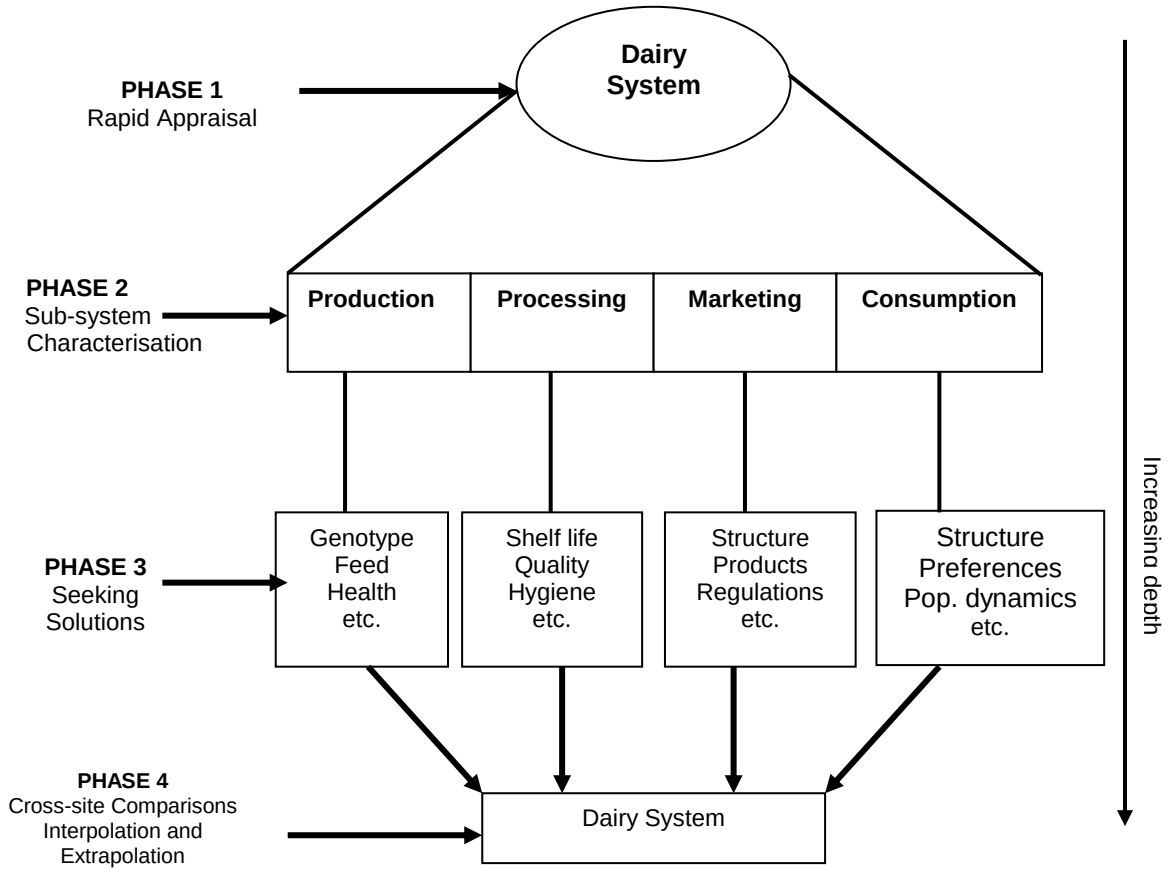
to consumers and the role of small informal milk traders, in spite of the relative state of development of the Kenyan formal dairy industry, is obvious.

1.1 Conceptual Framework

The conceptual framework used in carrying out this study derives from Rey et al (1993). According to this framework, a "dairy system" incorporates all areas and production systems producing, and the marketing channels delivering dairy products to consumers in urban centres, including the policy environment.

In this conceptual framework, a study site is defined by a consumer centre, with its dairy shed and the processing and marketing actors and processors linked to them. In the current characterisation survey, the consumer centre is Nairobi, while the other districts represent the milk shed, areas where milk is produced.

For convenience of investigation and analysis, the dairy system is broken up into four different subsystems namely: production, processing, marketing and consumption. Further, each subsystem is constituted by components representing distinct areas of examination and subsequent action. For instance, the production sub-system has genetic, feeding and health components among others. Below is a schematic representation of the conceptual construct described above.



In this conceptual framework, the process of research diagnosis and solution development has been categorized in phases from constraint and opportunity identification, to seeking solutions for dairy systems and finally to replications to comparable sites. The four phases are:

1. Appraisal (or typification) 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.

2. More detailed characterisation 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. The objectives of characterisation are:

    - To provide baseline data on the dairy system performance
    - To understand factors influencing dairy production: constraints and opportunities, farmers' rationale and objectives
    - To understand linkages between different subsystems and their influence on the development of the dairy system
    - To identify and prioritise researchable issues which make an impact on the development of dairy system (at the component level).

    The study described in this report fits into this characterisation level of analysis.

3. The third phase seeks ways to enhance the development of specific dairy systems. This phase is also called the intervention phase and its main objectives are to quantify impact of constraints, to design and test alternatives to enhance dairy production and to design and test methodologies.

4. Phase four is cross-site synthesis and involves extrapolation of the findings from phase 2 and phase 3 to areas with comparable agro-climatic and market access characteristics. An important objective in this phase will therefore be the replication of interventions in other dairy systems in other countries and continents.

Phase 1, the Appraisal, was conducted by SDP in 1998, and is presented in Omore et al (1999). This report presents results of the production system characterisation (Phase 2) in the target zone of Central Kenya.

2. Materials and Methods

2.1 Questionnaire Development

The methodology tested in the Kiambu pilot survey by MOA/KARI/ILRI (Staal et al, 1997) of using a structured questionnaire, was modified in line with the experiences gained and expanded to incorporate data needs of collaborating researchers.

The questionnaire was divided into sections covering household demographics, farm facilities and activities, livestock inventories, feeding, production performance, milk marketing and income ranking. It was pre-tested and the enumerators trained on it before it was then applied in the field.

2.2 Site Selection

Contrasting sites, representing combinations of dairy production potential and market access as judged by expert informants, were chosen as shown in Table 1 below (as mentioned Kiambu had been characterised earlier). It was then decided to select two Divisions per District that would be most indicative of dairy production potential within each District. Divisions were selected so as to reflect some contrasts in agro-ecological zone.

Table 1: Study Sites According To Criteria

Agro-climatic potential	Market access	District(s)
High	High	Kiambu
	Medium	Kirinyaga, Maragua, Murang'a,
	Low	Nyandarua (South)
Medium	High	Nairobi, Machakos
	Medium	Nakuru
	Low	Narok. (North)

More divisions were included in Nakuru as, along with Nairobi, they represent major urban consumption centres. In total sixteen Divisions in all the Districts were selected (Fig. 1).

The agro-ecological zones described by Jaetzold and Schmidt (1983) were used to make groupings of land-use systems. These are namely Sheep-Dairy (Upper Highlands1 and UH2), Tea-Dairy (Lower Highlands1 and UM1), Coffee-Dairy (Lower Highlands2, Upper Midlands2 and UM3), Horticulture-Dairy (UM4), Wheat-Dairy (LH3 and LH4) and the township areas, as Urban (Table 2.)

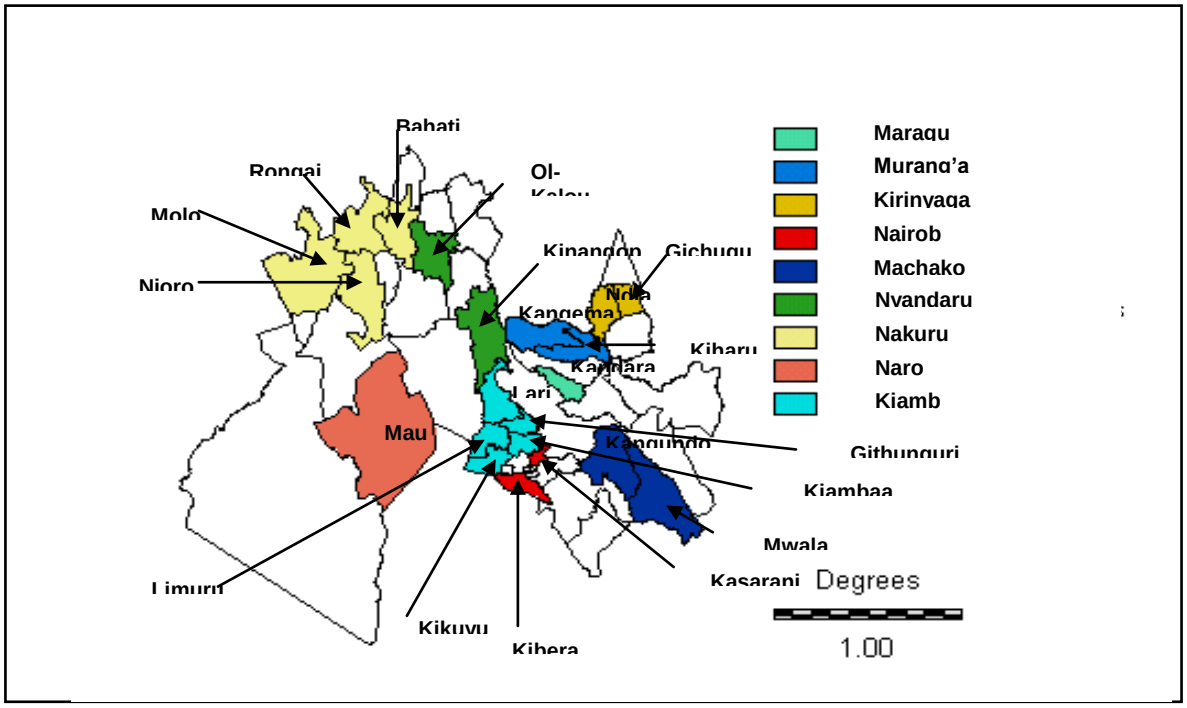


Figure 1: Divisions Within Districts Covered By Characterisation Surveys

Table 2: The Districts/Divisions And Land-Use Systems

District	Division	Agro-ecological zones	
Nakuru	Molo	Forest (UH0),	Sheep/Dairy (UH1, UH2)
	Njoro	Wheat/Dairy (LH3, LH4)	
	Rongai	Wheat/Dairy (LH3, LH4)	
	Bahati	Coffee/Dairy (LH2)	Wheat/Dairy (LH3), Urban
Narok	Olulung'a	Tea/Dairy (LH1),	Sheep/Wheat/Pyrethrum/Dairy (UH1, UH2)
	Mau	Wheat/Dairy (LH3, LH4),	Urban
Nyandurua	Kinangop	Forest (TAI.II),	Sheep/Dairy (UH1, UH2), Wheat
	Ol Kalou	Forest (TAI,II), Wheat (UH-LH3)	Sheep/Dairy (UH1, UH2),
Nairobi	Kasarani	Urban	
	Kibera		
Machakos	Kangundo	Marginal Coffee/Dairy (UM3)	
	Mwala	Subsistence/Horticulture/Dairy (UM4-UM5)	Coffee/Dairy (UM2, UM3)
Murang'a	Kiharu	Tea/Dairy (LH1, UM1),	Coffee/Dairy (UM2, UM3)
	Kagumo	Tea/Dairy (LH1, UM1),	Coffee/Dairy (UM2, UM3)
	Maragua	Tea/Dairy (LH1, UM1),	Coffee/Dairy (UM2, UM3), Hortculture/Dairy
Kirinyaga	Gichugu	Tea/Dairy (LH1, UM1),	Coffee/Dairy (UM3)
	Ndia	Tea/Dairy (LH1, UM1),	Coffee/Dairy (UM2, UM3)

Five Sub-locations were then selected randomly from each of the Divisions in each site to reflect the variation in land-use systems within sites (Appendix 1), resulting in 92 Sub-locations.

2.3 Calculation of the Sample Size

A stratified sampling method was used to select the sub-locations to be surveyed. Based on the agro-ecological zones described by Jaetzold and Schmidt (1983) and field knowledge, six major land use systems, namely coffee/dairy, horticulture/dairy, tea/dairy, sheep/dairy, wheat/dairy and Nairobi were identified in the eight districts. Three population density classes were identified: less than 200 inhabitants per Km^2, between 200 and 500, and more than 500 (C.B.S, 1994). As a result, twelve stratification groups were considered (not eighteen since some combinations do not exist such as tea/dairy in less than 200 density areas) and some combinations have been grouped to avoid obtaining very small groups.

The number of households to be surveyed in each sub-location was taken as a proportion of the households as estimated from the 1989 census figures (C.B.S., 1994). The sample size was obtained from calculating the number of observations potentially needed to estimate a difference between two means (with a confidence level of 95%, a coefficient of variation for the number of cows of 68% and to observe a level of difference of 20%)[1]. These calculations result in a minimum of 89 households per stratification group. The size of the sample in Nairobi was arbitrarily increased to 280 in order to increase the probability of including agricultural households. Then the sample size in each sub-location was calculated as a proportion of the number of households in the corresponding stratification group: sample size in sub-location i in stratification group j = (number of HH in i / total number of HH in j) x 89. If the calculated sample size was less than 10, it was then fixed at 10 in order to get enough observations at that level of analysis. The resulting sample size is 1389, with some heterogeneity between the sample size in each division. The smallest in any one division is 50 in Gichugu and the largest sample is 118 in Rongai. Annex 1 gives the sample size per stratification group and per sub-location surveyed.

2.4 Survey Procedure

Survey maps for each of the 82 sub-locations were created from ILRI geographical information systems (GIS) databases, using ArcInfo software. The survey enumerators, who had previously been trained in the use of the survey instrument, visited their assigned sub-locations and marked on the map the main landmarks (any permanent feature like a trading centre, a school, or a church). Two (or three) pairs of landmarks were then selected at random for each sub-location and line transects were drawn joining each pair. Sampling was thereafter done following as closely as possible the marked transects. Every 5^{th} household on the left and on the right was interviewed alternately, regardless of whether they were agricultural or kept dairy animals. In this way, a random sample of all sub-location households was obtained.

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[1] Calculation of sample size in each stratification group, to estimate a difference, is:

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

where z = 1.96 for 95% confidence interval, c is coefficient of variation, and d is level of difference. (Poate and Daplyn, 1993).

The questionnaires were completed through interviews with the household head or in his/her absence, the most senior member available or the household member responsible for the farm. Enumerators were asked to make appointments if this person was not available. Enumerators were selected among the front-line and supervisory extension staff of the MoA in each district. A supervisor checked each completed questionnaire in order to get as accurate information as possible. The data from the questionnaires were entered into EpiInfo data management software and checked for data entry errors. Descriptive statistical analyses were carried out using Stata software.

The questionnaire was divided into sections covering: household composition, labour availability and use; farm activities and facilities; livestock inventory; cattle feeding distinguishing between on-farm feed and purchased feeding; dairying with emphasis on milk production and milk marketing; livestock management and health services; household income and sources; and cooperative membership, cooperative services and milk consumption.

Simultaneous with the enumeration, of all the farms/households were geo-referenced using GPS mapping instruments by the SDP supervisors. The GPS points were downloaded using PCX5 software and with IDRISI used to show the spatial distribution of the farms/households.

3. Results From Descriptive Analyses

3.1 Overview

A total of 1,390 households were surveyed. This is fewer than the planned total of 1,401 mainly because in Mau Narok and parts of Molo and Njoro households had fled ethnic clashes, and enumeration was difficult. The results showed that a majority of rural households are agricultural (74.8% of the surveyed households) and many practice dairy farming (75.3% of the agricultural households). There is an increasing shift towards intensification of dairying through growing of fodder crops with “cut-and-carry” feeding systems and keeping of improved dairy breeds on the ever decreasing land available for agriculture.

3.2 Households

Below we examine the basic characteristics of the surveyed households, in order to place in context their agricultural and livestock production activities. Households’ characteristics such as whether agricultural or non-agricultural, composition, gender of household head, income and so on are presented in this section. Comparisons between districts are made and a discussion of the differences and similarities presented.

3.2.1. Proportion of Non-agricultural, Agricultural and Dairy (cattle keeping) Households

About 74% (1,015) of all households owned agricultural land and of these 73% had dairy cattle[2] (Fig. 2). This underlines the fact that a majority of rural households are engaged in agricultural activities and many practice dairy farming.

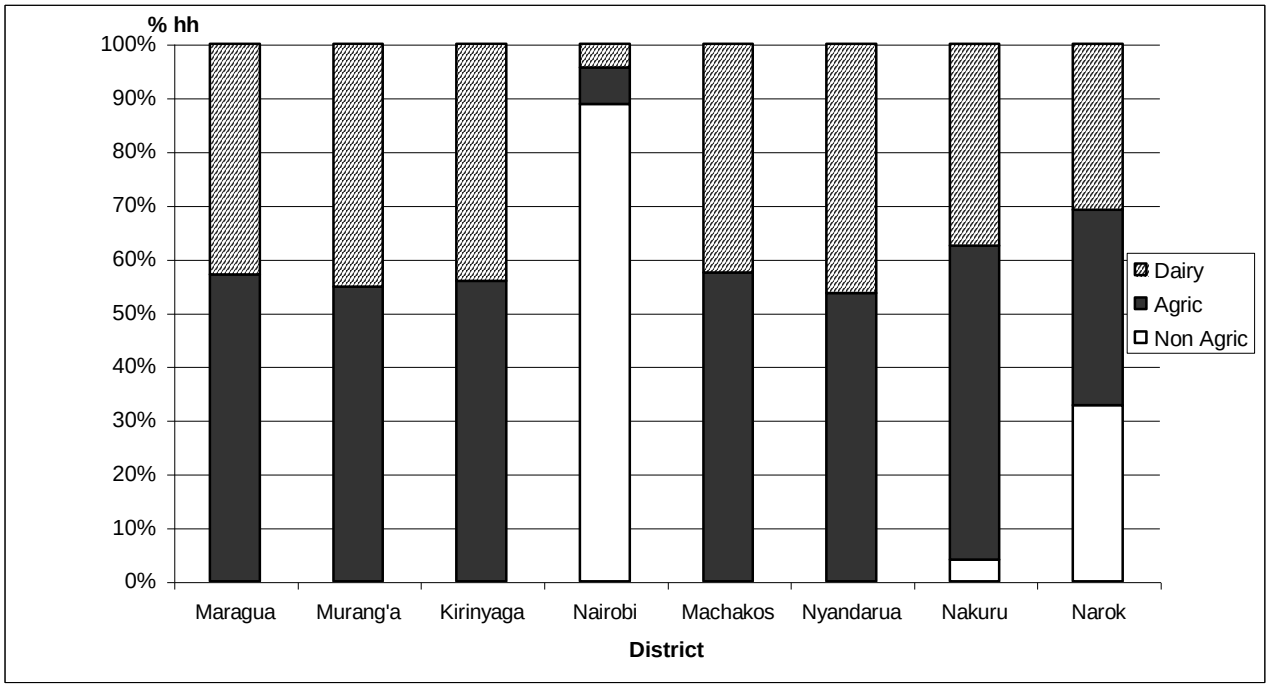

Figure 2: Percent Non-Agricultural, Agricultural and Dairy Households

In Nairobi over 90% of households were non-agricultural with Narok township sub-location also contributing to the high percentage (47%) of non-agricultural households found in Mau Narok. Among other districts, Nyandarua and Kirinyaga showed the highest proportion of agricultural households (nearly 100%), as well as a high proportion of dairy farmers.

3.2.2 Household Head Gender Differentiation and Education level

The head of a household was defined as the person most available at the homestead and who makes the day-to-day decisions concerning food, expenditures, farm enterprises etc. As shown in Fig.3, on average about three quarters of farm/households were headed by males, with the remainder being female headed. This compares closely to the figure of 28% female headed for households in Kiambu (MOA/KARI/ILRI 1998). The percentage of female-headed households was highest in Machakos (43%) as the male spouses are often away working in Nairobi. In Narok most households were male headed (88%) probably because the society is polygamous and less inclined toward urban employment.

[2] Dairy cattle are defined as those having some measure of Bos taurus dairy breed genes, thus either cross-bred or grade.

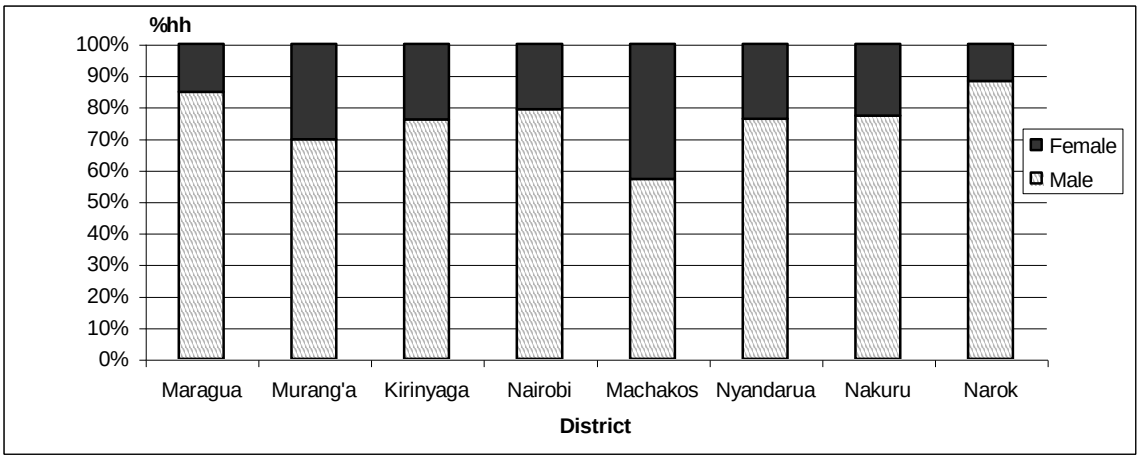

Figure 3: Gender of Household Head by District

The education level of the household head was also analysed as shown in Fig. 4. The majority of the sample households in all Districts (68-85%) had some primary or secondary level education. The mean age of the household head was 47 years.

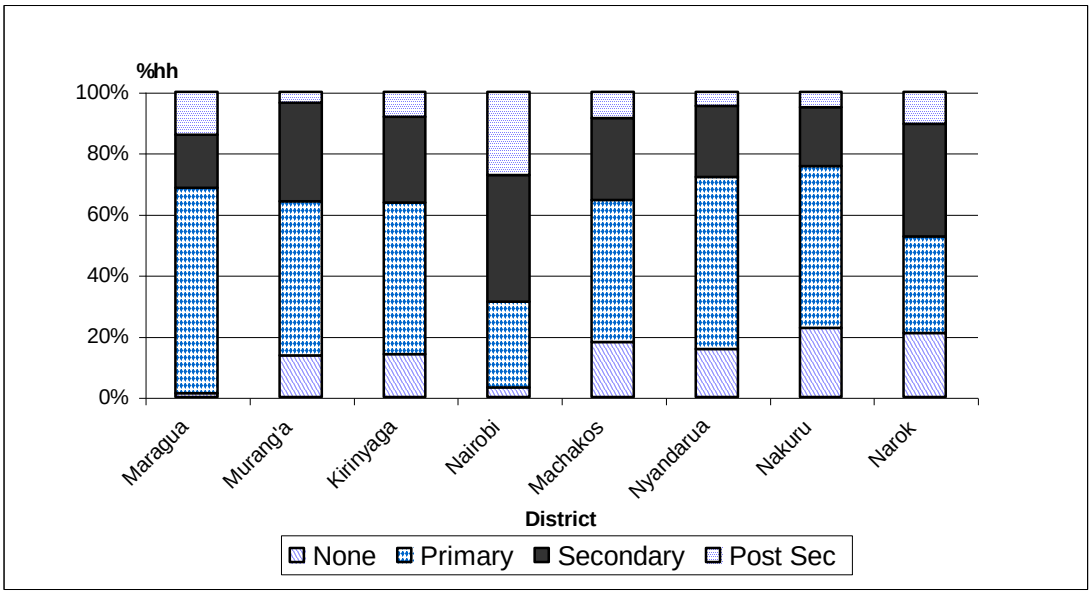

Figure 4: Education Level Of The Household Head

Respondents were also asked to state the primary activity of the household head. Among other things, this question was meant to elicit information on off-farm employment opportunities for the household head. Results showed that for most (52%) of them farm management was their primary activity. Table 3 below gives the proportion of household heads whose primary activity was off-farm employment.

Table 3: Proportion of Household Heads with Off-Farm Employment

District	%
Maragua	36.36
Murang'a	32.31
Kirinyaga	18.00
Nairobi	89.08
Machakos	37.50
Nyandarua	23.85
Nakuru	41.19
Narok	68.42
Overall	47.93

3.2.3 Household Sizes and Composition

The average household size, as shown in Table 4, was 5.7 (sd 3.2) persons centred around approximately 2 adults in the age group 23 to 65 years. The other groupings of less than 8 years, 8 to 14, 15 to 22 and over 65 years had 1.2, 1.1, 1.0 and 0.2 persons respectively. This scenario varied across sites and indicated that the largest households occurred in Machakos (7.1 members). Household sizes are expected to influence labour availability for dairy and crop production, although conversely, small households may indicate low rural employment opportunities, leading to rural-urban migration.

Table 4: Household Sizes and Composition

Number in each Age Category (sd)						
District/Years	< 8	8-14	15-22	23-65	>65	Total
Maragua	0.8 (1.0)	1.4 (1.6)	0.7 (1.0)	2.1 (1.1)	0.3 (0.6)	5.2 (2.7)
Murang'a	0.8 (1.1)	0.1 (1.1)	0.9 (1.7)	1.8 (1.1)	0.3 (0.6)	4.6 (2.9)
Kirinyaga	0.1 (1.2)	0.1 (1.2)	0.9 (1.1)	2.1 (1.3)	0.3 (0.7)	5.3 (2.5)
Nairobi	1.1 (1.1)	0.7 (1.0)	0.9 (1.0)	2.3 (1.7)	0.1 (0.3)	5.0 (2.8)
Machakos	1.7 (1.7)	1.2 (1.2)	1.1 (1.3)	2.6 (1.4)	0.4 (0.6)	7.1 (3.0)
Nyandarua	1.6 (1.7)	1.2 (1.3)	0.9 (1.4)	2.5 (2.7)	0.2 (0.5)	6.4 (4.0)
Nakuru	1.4 (1.6)	1.2 (1.4)	1.2 (1.5)	2.4 (1.6)	0.2 (0.5)	6.3 (3.3)
Narok	1.1 (1.7)	1.1 (1.3)	0.1 (1.4)	2.2 (1.0)	0.1 (0.2)	6.3 (3.7)
Average no.	1.2 (1.5)	1.1 (1.3)	1.0 (1.4)	2.2 (1.6)	0.2 (0.5)	5.7 (3.2)

3.3. Farm Holdings

3.3.1 Land Use And Cropping Practises

The survey attempted to quantify the production of the cash and food crops, including coffee, tea, maize, beans and Irish potatoes, and to identify interactions with dairy production and the growing of animal fodder (mainly napier grass). Farmers caution, however, that even within Districts crops are region-specific and any generalisation could be misleading.[3]

Coffee was confined to Central Province and Machakos with average acreage being 0.83, 0.39 and 1.01 for Maragua, Murang'a and Kirinyaga respectively and 0.76 in Machakos for the dairy households (Table 5). Tea was also predominantly grown in Maragua, Murang'a and Kirinyaga with 0.10, 0.34 and 0.14 acres recorded per farm. Wheat was grown in the southern Rift Valley Districts with Narok having the largest tracts (14.69 acres). Growing of napier grass as a fodder has been widely adopted across all Districts, apart from Narok, where the predominant system for keeping cattle is grazing. The acreages of napier may be underreported because of difficulty of measuring napier planted on boundaries, ridges and as terraces.

Table 5: Acreage of Food and Cash Crops

District	Type of hh	N	Coffee	Tea	Wheat	Napier	Maize	Beans	Irish Potatoes
Maragua	Dairy	58	0.83	0.10	0.00	0.43	0.55	0.26	0.06
	Non-dairy	16	0.45	0.01	0.00	0.10	0.47	0.16	0.01
Murang'a	Dairy	143	0.39	0.34	0.00	0.56	0.56	0.23	0.04
	Non-dairy	30	0.17	0.49	0.00	0.39	0.43	0.21	0.02
Kirinyaga	Dairy	73	1.01	0.14	0.00	0.33	1.13	0.71	0.15
	Non-dairy	17	0.62	0.03	0.00	0.04	0.44	0.37	0.08
Nairobi	Dairy	13	0	0	0.00	3.46	0.99	0.06	0.00
	Non-dairy	6	0.00	0.00	0.00	0.00	0.13	0.09	0.00
Machakos	Dairy	76	0.76	0	0.02	0.19	1.09	0.83	0.01
	Non-dairy	25	0.61	0.00	0.00	0.03	0.52	0.51	0.03
Nyandarua	Dairy	91	0.01	0.01	0.74	0.24	0.99	0.28	0.80
	Non-dairy	13	0.00	0.00	0.00	0.01	0.30	0.08	0.311
Nakuru	Dairy	216	0	0	0.65	0.18	1.35	1.03	0.26
	Non-dairy	103	0.00	0.00	0.08	0.01	0.74	0.65	0.13
Narok	Dairy	32	0	0	14.69	0.00	1.52	0.92	1.50
	Non-dairy	6	0.00	0.00	0.00	0.00	2.03	0.61	

[3] The sample of agricultural/dairy farmers in Nairobi was small and included a large farm with 265 acres and 170 animals which biases the mean values for Nairobi.

3.3.2 Land Tenure and Farm Size

The size of land holding per household varies greatly, and is generally seen as one of the main determinants of the intensification level (Table 6). In the Districts where land sizes are small and land is thus a primary constraint to production, farmers have an incentive to intensify and the main system of keeping cattle is “stall feeding”. Mean land holding was 6.6 acres (2.4 hectares) with the larger farms in Narok and Nyandarua (18.8 and 13.4 acres respectively) and the smaller ones in the High-Medium sites (Murang’a, Maragua, Kirinyaga) with 3.1, 3.1 and 3.8 acres respectively. Most farms had been established nearly 20 years ago and in three quarters of the cases remained the same size since.

Table 6: Total Land Sizes, Number of Plots and Years Since Establishment.

District	Total land (acres)	No. plots	Years est.	Acreage same as at est. (%)
Maragua	3.1 (5.6)	2.1 (7.1)	22.6 (11.1)	78.4
Murang’a	3.1 (3.2)	1.9 (7.1)	23.0 (11.5)	74.2
Kirinyaga	3.8 (3.5)	1.4 (0.6)	20.4 (14.0)	72.4
Nairobi	7.1 (20.3)	2.1 (1.3)	8.1 (7.8)	76.2
Machakos	9.5 (11.5)	1.1 (1.1)	26.8 (14.2)	67.2
Nyandarua	13.4 (20.0)	1.7 (1.2)	16.8 (11.8)	62.8
Nakuru	5.3 (9.4)	1.8 (6.6)	14.7 (7.1)	87.7
Narok	18.8 (23.5)	1.6 (0.9)	11.8 (8.0)	57.1
Total/Av.	6.6 (11.9)	1.8 (5.4)	18.9 (11.7)	77.7

Majority of households surveyed had only a homestead plot and often one other separate plot. The land tenure of the homestead plot was freehold (with title deed) on 72% of farms while the remaining 28% were inherited (traditional tenure). For those with second plots half were freehold, 30% rented and 15% inherited. This confirms that significant numbers of farmers hire land, where available, to grow crops and fodder.

To investigate changes over time in types of crops grown in the area, respondents were asked to state crops grown now but not 10 years ago, and conversely, crops grown 10 years ago but not now. Figure 5 and Figure 6 below summarises the changes that have occurred in types of crops cultivated according to the survey results.

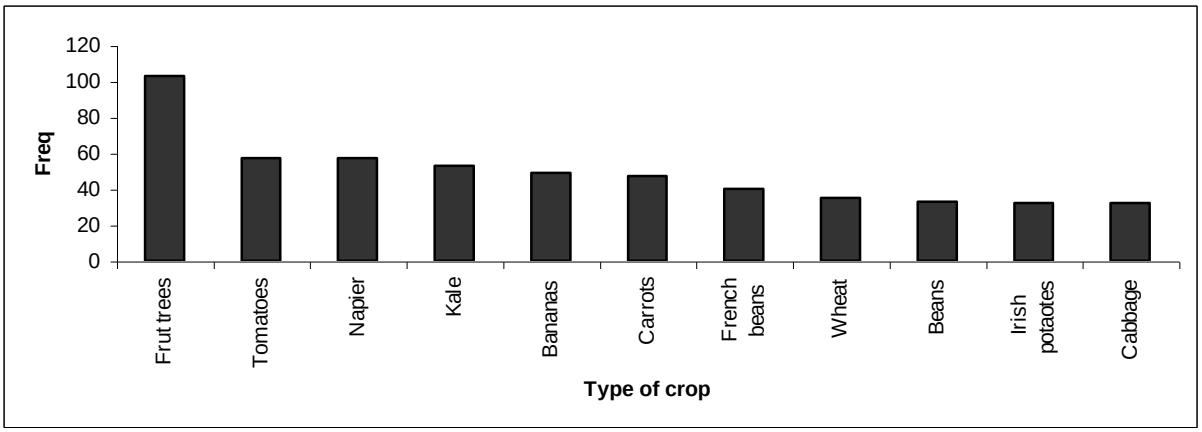

Figure 5: Frequency of households growing crop now but not 10 years ago

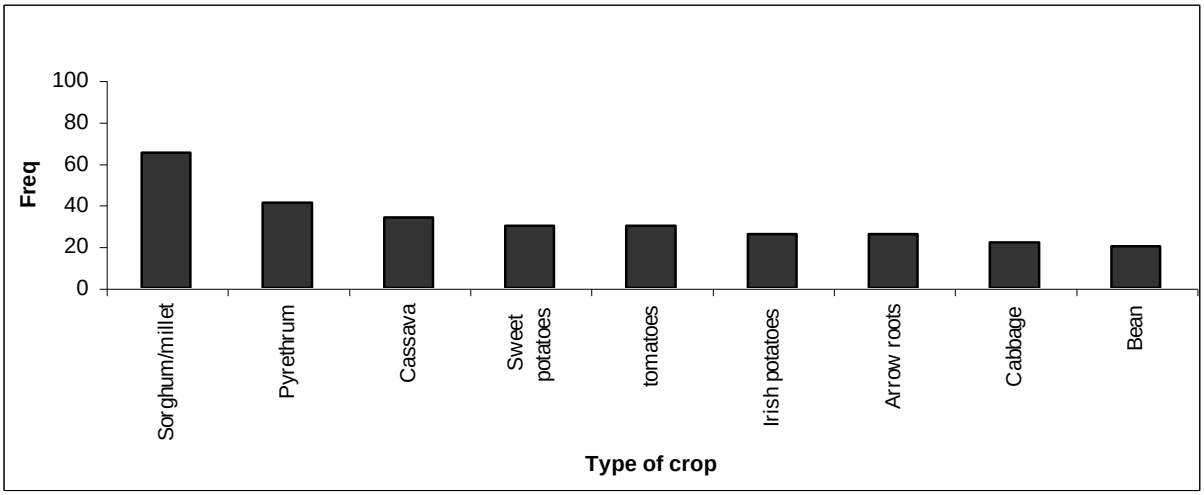

Figure 6: Frequency of households growing crop 10 years ago but not now

From Figure 5, it is apparent that growing of Napier grass, together with that of fruit trees and tomatoes, has increased over the last 10 years leading to the time of the survey. The increase in households growing napier may be an indication of a shift towards a more intensive mode of dairy production, prompted by either decreasing land sizes or better knowledge of dairy technologies. Conversely, the results suggest that farmers are abandoning the growing of traditional crops such as sorghum/millet, cassava and sweet potatoes, as high as 60% of respondents in the case of sorghum/millet. The later findings are similar to those for Kiambu, where most households reported a decline in cultivation of sweet potatoes (Staal et al, 1998). Pyrethrum was another crop whose growing was reported to have declined.

Table 7 shows allocation of land to crops and pasture. Arable land is here defined as the total land size minus pasture and includes cropped and fallow land. For Maragua, Kirinyaga and Nairobi, as in Kiambu District, all land, including that planted in fodder, is 100% arable (cropped). Nyandarua has 67% of the land as pasture (mostly established pastures) with only a third of the total land being cropped. In Narok the arable to pasture ratio is higher than expected because animals are grazed on communal land, and the percentage of arable land reported include only cropped and fallow and excluded the total land owned and/or communal pasture.

Table 7: Average Arable and Pasture Allocation (acres)

District	Arable		Pasture	
	Mean	**Sd**	**Mean**	**Sd**
Maragua	3.2	5.0	0.0	0.1
Murang'a	3.1	3.2	0.2	0.6
Kirinyaga	4.3	4.6	0.0	0.1
Nairobi	5.3	17.1	0.0	0.0
Machakos	8.6	13.4	0.6	2.1
Nyandarua	5.2	8.0	3.5	8.6
Nakuru	3.8	5.8	1.0	3.6
Narok	17.3	23.8	0.4	1.2

3.3.3 Farm Infrastructure and Transport

The majority of agricultural households (45%) had only manual farm transport available. This includes bicycles and wheelbarrows. About 44% had no farm transport whatsoever with the remaining households having combinations of animal drawn carts and manual transport (7%) or motorised and manual transport (4%). It was clarified that motorised transport was actually in many cases a group organised affair and not individually owned transport.

3.3.4 Labour Resources

The results reflect those households hiring external labour for mainly dairy related activities. "Mainly" means that a hired labourer spends more than 50% of their time on dairy activities . A high percentage can be explained in two contrasting ways; for highly intensified zero grazing systems labour is necessary to carry out the "cut and carry" feeding activities (labour intensive), while on the other hand, the extensive systems where animals are grazed, the hired labour is required for herding. In general 40% of households hired no

labour relying solely on family labour (Table 8). This figure reflects the results from Kiambu (Staal et al, 1998). Of the 60% hiring labour, two thirds of it is only casual labour, the rest being split between those hiring only permanent (long-term) labour, 13%, or both types (20%). These findings again suggest the important role of dairying in generating employment within producer communities.

Table 8: Percent Hiring Casual or Permanent Labour or Both

District	No hired labour	Casual labour only	Permanent labour only	Both casual and permanent labour
Maragua	45.2	45.2	0.0	9.5
Murang'a	36.0	48.4	3.8	11.8
Kirinyaga	31.3	56.3	6.3	6.3
Nairobi	64.0	16.0	16.0	4.0
Machakos	36.4	38.8	13.2	11.6
Nyandarua	29.1	47.3	7.3	16.4
Nakuru	45.0	39.0	7.1	8.8
Narok	31.0	31.0	11.9	26.2
Average no.	39.7	40.2	8.2	11.8

The allocation of family and hired labour to dairy activities is summarised in Table 9. Overall the primary responsibility for the dairy activities are 36%, 24%, 12%, 10%, 3%, 9% and 6% for adult males, adult females, both, children, permanent and casual labourers respectively. The high percent for males can be attributed to them being responsible mostly for obtaining breeding or veterinary services (62%) and spraying or dipping of animals (56%). Women, on the other hand, are evenly involved in all activities more so in the milking and sale of milk (Narok and Machakos 83% and 64% of dairy households respectively report the adult females doing the milking). Child labour is virtually non-existent except in Narok where they are responsible for grazing (29%), selling milk (37%) and watering the animals (29%). The Table also shows that permanent labour is hired mainly for dairy activities and is corroborated by the farmers who say casual labour is used for crops management while permanent labour is used for herding cattle. In addition casuals are rarely given food whilst permanent labourers are given both food and housing.

Table 9: Allocation of Household and Hired Labour to Dairy Activities (%)

Dairy activity	Adult male	Adult female	Both (m/f)	General Household	Children	Perm. Labour	Casual Labour
Graze/cut feed	30	24	12	9	4	15	6
Process feed	17	25	29	10	1	12	6
Tend fodder	34	17	8	21	1	7	12
Milking	26	41	11	8	2	10	2
Sale of milk	33	35	9	7	6	8	2
Spray/dipping	56	11	9	8	3	9	4
Cleaning shed	35	22	13	13	1	8	8
Obtain AI/Vet	62	14	10	5	2	6	1
Water animals	32	31	10	12	5	5	5
Overall av.	36	24	12	10	3	9	6

3.4 Livestock

3.4.1 Cattle Numbers and Breed Types.

Dominant genotype differs according to the system for keeping cattle with improved animals being present where the main system is stall-feeding while local animals are found in grazing areas. Cattle rustling and tribal clashes have distorted the cattle inventory in Nakuru with farmers saying numbers are usually higher.

As shown in Table 10 the mean number of Zebu, cross and grade cattle per household were 6.9 (sd 9.6), 3.8 (sd 4.3) and 3.5 (sd 5.0) respectively. As expected, the largest herds were in the extensive grazing systems in Narok with 16.2 animals predominantly Zebu. Nyandarua District also had relatively large herds (5.5) though these are all upgraded dairy animals, and land sizes are larger. The sample in Nairobi was small but showed the trend towards intensification in that the dairy farmers are keeping on average 7.5 cows, all grade on very small pieces of land.

Predominant dairy breeds reported are Friesian (42%), Ayrshire (18%), Guernsey (12%) and Jersey (3%) with the *Bos indicus* (Zebu, Sahiwal and Boran) reported in 25% of farms. This agrees with the farmers views, aired during the feedback meetings, that the Friesian and Ayrshire are preferred due to their higher milk production.

Table 10: Cattle Inventory and Means per Household Reporting

District		Zebu		Dairy		Herd size	
	N	Mean	SD	Mean	SD	Mean	Mean
Maragua	61	0	0	2.0	1.0	2.0	1.0
Murang'a	148	0.1	0.3	2.2	1.5	2.3	1.5
Kirinyaga	76	0.1	0.5	2.1	1.2	2.2	1.1
Nairobi	14	0.1	0.5	7.4	17.6	7.5	17.5
Machakos	78	3.1	2.9	0.8	1.8	3.9	3.1
Nyandarua	98	0.1	0.3	5.4	4.8	5.5	4.7
Nakuru	230	0.6	3.2	4.1	5.1	4.7	5.7
Narok	36	13.8	14.2	2.4	4.7	16.2	13.4
Overall	741	6.9	9.6	3.5	5.0	4.3	

3.4.2 Herd Sizes And Structures

From Fig.7a below it can be seen that overall, herds are composed of mostly adult cows (45%) which together with the heifers and female calves account for nearly two thirds of the animals in the herds. Bulls formed only 6% of the herd. The similar number of female and male calves suggests that the males did not leave the herd until after weaning.

Maragua is shown in Fig. 7b and represents other parts of central Kenya were land is a constraint. Here cows and heifers account for 76% of the herd and the relatively higher number of bulls are because they are kept for draught and later sold for meat. Herd composition is very diverse especially in Narok and Nyandarua where land size is not a constraint (Narok, Fig. 7c).

In Narok and Machakos the Zebu cattle are not mainly kept for income from sales of milk but for production of milk for home consumption and cash from sales of steers hence herds also have higher number of males. In Nyandarua the farmers report that one in every three households keeps a breeding bull.

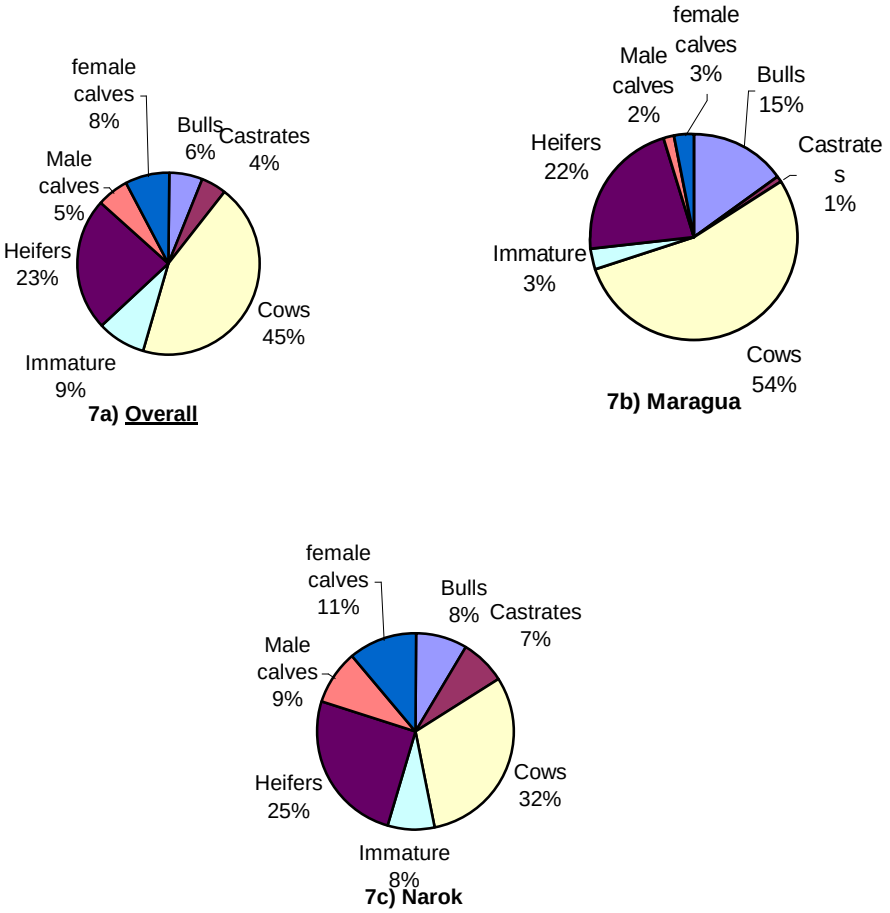

Figure 7: Herd Composition (Overall, Maragua and Narok)

3.4.3 Non-Cattle Livestock Inventory

Smallholder farmers keep other livestock beside cattle (namely chickens, sheep, goats, donkeys for farm transport and a few pigs. Table 11 shows the proportion of all agricultural households reporting having the different livestock, the mean numbers and standard deviations. The main livestock kept are local poultry kept by 76% of all agricultural households, local goats by 37%, sheep (36%) and donkeys (16%). Local chickens are kept by 65% to over 90% of households in all Districts with an average of 4 to 12 in number. The local goats are predominantly in Machakos and Narok with 67% each but with flocks in Narok being much larger (average of 24 animals) when compared to 3 goats in Machakos.

A lower percentage of households reported keeping sheep, with only Nakuru, Narok and Nyandarua reporting about 70% each. Whereas Narok will have the hair sheep breeds like the Red Maasai the other 2 Districts have predominantly wool sheep e.g. Doper and Merino. Nairobi has the predominance of commercial layers, broilers and pigs with 8, 27 and 36% reporting. This is probably due to the nearness of input markets for feed and the sales outlets to hotels, institutions etc.

Table 11: Proportion (%) of Agric. Households with Livestock other than Cattle, the Mean Number and SD

	Goats		Sheep	Poultry			Donkeys	Pigs
	Local	Dairy		Local	Layers	Broilers		
Maragua	32.3	6.6	17.2	65.3	6.6	0	1.6	4.9
	(0.7 ± 1.3)	(0.1 ± 0.7)	(0.5 ± 0.5)	(3.9 ± 4.4)	(19.2 ± 19.2)		(0.0 ± 0.3)	(0.3 ± 1.6)
Murang'a	42.3	6.3	14.1	68.3	1.4	0.7	0	4.8
	(1.2 ± 1.8)	(0.2 ± 0.7)	(0.4 ± 1.4)	(4.0 ± 4.5)	(1.1 ± 12.5)	(0.0 ± 0.1)		(0.3 ± 0.2)
Kirinyaga	36.4	5.5	13.7	83.5	1.4	0	0	8.2
	(0.9 ± 1.5)	(0.2 ± 0.7)	(0.3 ± 0.9)	(8.1 ± 9.0)	(0.0 ± 0.4)			(0.8 ± 5.9)
Nairobi	28.6	0	15.4	35.7	7.7	26.7	0	35.7
	(6.8 ± 17.8)		(6.8 ± 16.8)	(4.6 ± 10.7)	(15.4 ± 55.5)	(69.7 ± 140.6)		(10.0 ± 20.6)
Machakos	67.4	0	19.0	94.6	1.3	0	13.0	0
	(3.1 ± 3.4)		(0.8 ± 2.0)	(7.4 ± 5.6)	(1.6 ± 13.8)		(0.1 ± 0.4)	
Nyandarua	3.1	1.0	69.7	92.3	3.1	0	23.5	1.0
	(0.1 ± 0.3)	(0.0 ± 0.1)	(6.2 ± 9.5)	(8.9 ± 8.4)	(0.1 ± 0.1)		(0.3 ± 0.7)	(0.1 ± 1.4)
Nakuru	17.7	1.4	69.9	91.5	2.7	0.5	18.0	8.7
	(0.7 ± 3.0)	(0.1 ± 0.6)	(4.0 ± 5.9)	(12.0 ± 11.0)	(2.3 ± 20.8)	(1.4 ± 20.2)	(0.2 ± 0.7)	(0.3 ± 3.3)
Narok	66.7	11.8	71.4	76.3	5.9	5.9	74.3	0
	(24.0 ± 21.4)	(1.3 ± 4.6)	(18.4 ± 22.4)	(8.5 ± 8.2)	(0.5 ± 2.2)	(1.0 ± 5.5)	(2.5 ± 2.6)	
Overall.	36.8	4.0	36.3	76.0	3.8	4.2	16.3	7.9

3.4.4 Feed Resources and Production

The dominant systems for keeping cattle were defined as only stall feeding (zero grazing), grazing and mainly grazing with some stall-feeding (semi-feeding (semi-zero grazing). The semi-zero grazing described is paddock grazing on improved pastures with a little “cut-and-carry” as in Nyandarua or enclosing of animals in semi-permanent structures with predominantly “cut-and-carry” with a little grazing as in parts of central Kenya. Overall the main production systems were semi-zero grazing for 38% of farms, zero grazing for 37% and grazing for 25% of farms mostly in Narok (Figure *).

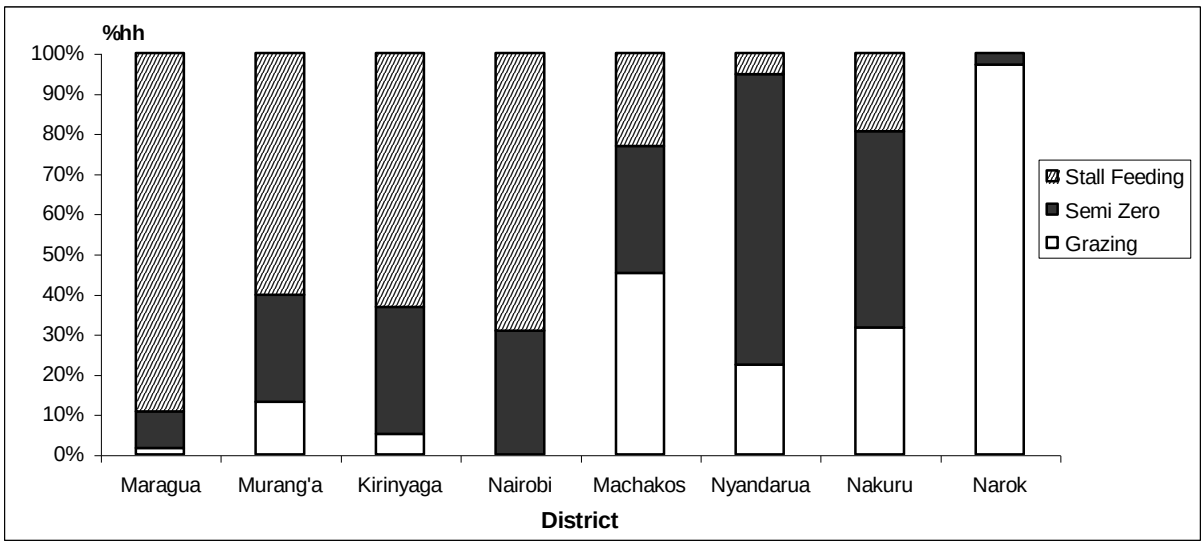

Figure 8: Main Feeding System Currently Practised

In Narok and Machakos the pasture is grass. After harvesting wheat, animals graze on the fields as well. In Nyandarua, rhodes and rye grasses are grown for pasture, but due to overgrazing, have been taken over by star, couch and wire grasses, which are of poorer quality.

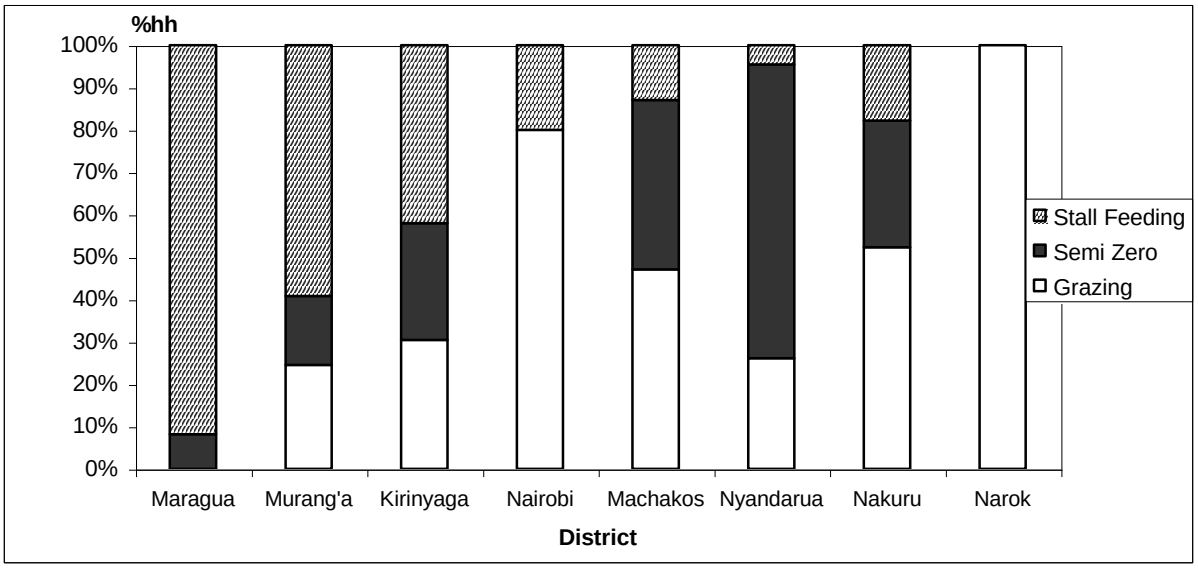

Figure 9: Main Feeding Systems 10 Years Ago

Strategies employed to alleviate the limited feed supply include the feeding of crop by-products, fodder cultivation on roadsides and reliance on fodder markets. There is an increasing shift towards intensification of dairying through growing of fodder crops with “cut-and-carry” feeding systems and keeping of improved dairy breeds on the ever decreasing land available for agriculture. Fodder production and feeding systems were consistent with the farmers’ reports and changes in feeding systems was attributed to decreasing land holdings with subsequent pressure on land. Even those reporting grazing their animals are not doing so on their own land but in the forest reserves, along the roadsides and on fallow plots.

Farmers were asked to record feeds they use now and not 10 years previously and those they used previously and no longer use them. From Figure 10 below it can be inferred that use of napier, maize stover (mostly dry stover), mineral salts, weeds and other crop residues has gone up while use of concentrates and roadside grasses has gone down. This is as expected except for decreased use of concentrates probably due to the rising costs relative to the prices paid out for milk. Concentrate feeding now is not at recommended levels because many farmers agree they use it to relax the cows when milking and not really for increased milk production. Farmers also expressed concern on the quality of concentrates.

The project is testing the intervention of better targeting concentrate feed to take advantage of the physiological ability of cows in early lactation to convert concentrate feed more efficiently. Feeding in Nairobi is mainly on rations formulated from fodder (napier, grass, vines) and agro-industrial waste like brewer's waste, barley husks, pineapple waste, French beans and passion fruit waste.

Figure 10: Changes in Feeds Used Now and 10 Years Previously

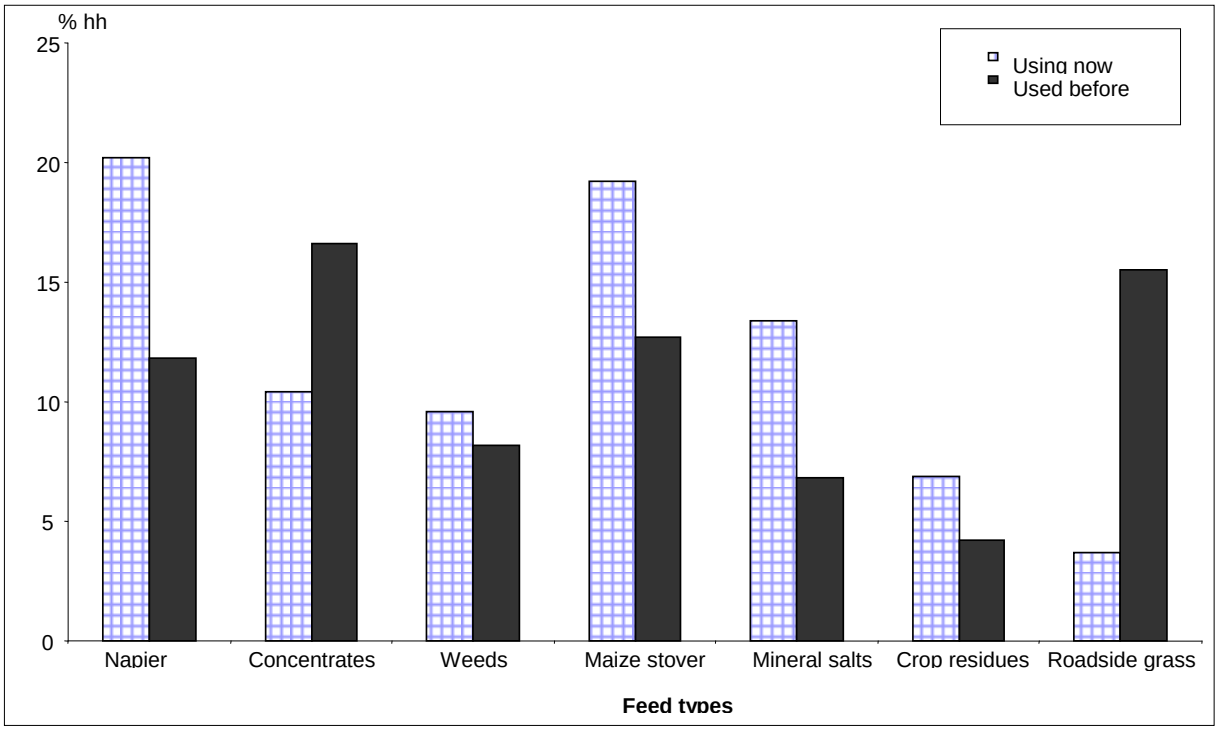

Table 12 and 13 give the results for the major feeds namely Napier grass, concentrate feeds, garden weeds, maize stover (dry and/or green), mineral salts and any others unique to a particular District.

Table 12: Major Feeds Used Now and Not 10 Years Previously (% of Dairy Households)

District	Napier	Concentrates	Weeds	Maize stover	Mineral salts	Other
Maragua	22.6	9.8	10.4	20.1	10.4	
Murang'a	22.3	4.6	13.7	20.3	13.7	
Kirinyaga	6.7	13.3	-	13.3	13.3	33.3 Hort.
Nairobi	10.5	21.0	5.3	7.9	2.6	15.8 Brewers
Machakos	32.3	9.7	5.4	12.9	17.2	
Nyandarua	19.4	25.0	3.7	14.8	11.1	
Nakuru	14.6	13.0	7.5	21.1	15.9	
Narok	-	-	33.3	33.3	-	33.3 Crop res.

Roadside grazing has declined dramatically in Murang'a, Machakos and Nakuru as reported by 20, 39 and 27 % of dairy farmers respectively (Table 13). This might have been as a result of decreased sizes of road reserves, their in-accessibility and

the knowledge that animals pickup more ticks when grazed hence more prone to TBDs.

Decreased use of vegetable by-products like pyrethrum in Nyandarua and horticultural waste would probably mean they are not grown on as large a scale as before.

Table 13: Major Feeds Used 10 Years Previously and Not Anymore (% of Dairy Household)

District	Napier	Concentrates	Weeds	Maize stover	Mineral salts	Other
Maragua	25.6	13.3	11.1	23.3	13.3	
Murang'a	6.5	18.3	7.5	14.0	-	Roadside 20.4
Kirinyaga	-	50.0	-	-	12.5	Hort. 12.5
Nairobi	-	-	100	-	-	-
Machakos	10.7	-	25.0	3.6	-	Roadside 39.3
Nyandarua	11.3	18.9	3.8	7.6	7.6	Pyreth. 13.2
Nakuru	4.9	19.5	-	7.4	1.2	Roadside 26.8
Narok	-	-	-	-	-	-

Table 14 quantifies the feed based on farmer recall. Average quantities, in kg per day, were reported for "cut and carry" fodder and crop residues, and for concentrates and other agro-industrial by-products. Grazing was estimated in hours.

Maragua, Murang'a and Kirinyaga, practising predominantly stall-feeding, reported 31.6, 22.9 and 47.8 kg of fodder given to all the animals daily. In addition the animals get 0.8, 8.1 and 12.1 kg. of concentrate. Given that the herd sizes in these Districts is on average 2 cows, it would be correct to assume they get 15 to 25 kg fodder and 4 to 6 kg concentrate (probably twice a day at milking as is the practise). Under-nutrition of the animals is evidenced by the low amounts of fodder and the flat rate concentrate feeding whose effects would not be felt because the animals are not meeting their dry matter requirements.

Narok is predominantly grazing with farmers reporting grazing the animals for almost 9 hours in a day. Machakos, Nyandarua and Nakuru also graze the animals most of the day with some supplementation with a little fodder and concentrates. Longitudinal studies in Nakuru (Rongai) and Nyandarua (Ol Kalou) will attempt to quantify over a year the feed available to these animals.

Table 14: Daily Grazing Hours, and Quantities of Fodder or Agro-industrial by-Products Fed (Kg)

District	Grazing	Fodder	By-products
Maragua	0.1	31.6	0.8
Murang'a	1.4	22.9	8.1
Kirinyaga	1.2	47.8	12.1
Nairobi	1.5	2.9	2.7
Machakos	4.4	6.2	0.6
Nyandarua	6.5	8.8	1.0
Nakuru	5.2	1.5	11.3
Narok	8.8	0	0

Water supply for livestock is not adequate and farmers are forced to trek their livestock for long distances in search of water. From Table 15 below it can be seen that only in Nairobi and Nakuru, with understandably the best infrastructure, do 90% and 30% of farmers respectively report using piped public water. The majority, 34%, have on-farm shallow wells that are prone to drying in the drier seasons. Nearly a quarter of farmers either take the animals to drink from rivers and dams especially so in Nyandarua and Narok or have to trek long distances down steep slopes to collect water from the rivers (Maragua). About 18 % report carting water that they have to buy, from private pumps, many of which are also a good distance away.

Table 15: Sources of Water for the Dairy Animals

District	Carted	On-farm well	Piped water	Rivers/dams
Maragua	11.1	9.3	14.8	64.8
Murang'a	26.2	16.2	20.0	37.7
Kirinyaga	55.6	23.8	14.3	6.3
Nairobi	8.3	-	91.7	-
Machakos	16.7	37.2	-	46.2
Nyandarua	12.4	61.9	19.6	6.1
Nakuru	25.0	25	29.6	20.4
Narok	8.6	45.7	2.9	42.9
Overall	18.2	34.0	13.0	23.1

3.4.5. Livestock Breeding Management

Smallholder farmers use artificial insemination (AI) services or rely on communal bulls where private or public AI services cannot be accessed easily. Very few farmers raise bulls for breeding on their own farms because they would rather use their limited fodder supplies for cows and female replacements. A shortage of own-produced replacements due to low calf survival and heifer and cow mortalities implies that many farmers obtain replacements from large-scale farms. Breeding is an overall constraint due to the collapse or lack of Artificial Insemination (AI) services so a large number of farmers are inadvertently using bulls of unknown pedigree and probably born on the farm thus posing threats of in-breeding. Over 71% used bulls as the natural source of service (Table 16), with the rest using artificial insemination from private practitioners (14.6%), dairy co-operatives (7.2%), Government (5.8%) and other sources like church NGOs (0.7%). Some complaints were made of private veterinarians not being successful due to poor heat detection, infertility problems with the cow or low semen quality.

Table 16: Breeding and Source of Service (%)

District	**Pregnancy rate**	Source of service				
		Bull	**GOK**	**Coop.**	**Private**	**Others**
Maragua	41.7	46.9	-	-	51	-
Murang'a	39.5	66.7	2.7	20.7	9	-
Kirinyaga	50.7	50	20.6	22.1	4.4	2.9
Nairobi	50.0	18.8	3.1	-	78.1	-
Machakos	30	76.6	9.4	4.7	-	7.8
Nyandarua	51.6	78.7	1.7	10.1	9.6	-
Nakuru	52.6	60.2	8.6	3.2	18.2	-
Narok	69	100	-	-	-	-
Overall	48.8	71.4	5.8	7.2	14.6	0.7

3.4.6 Livestock Health Problems and Management Practises

Infectious and vector-borne diseases can be locally important but often their incidence decreases with increasing subdivision of farms and stall-feeding. The main health problems reported were attributed to East Coast fever (47% of dairy household), anaplasmosis 16% and mastitis, worm loads and respiratory problems 7% each (Table 17). Tick-borne diseases like ECF and anaplasmosis are major causes of deaths in extensive farming systems, warmer climates and lower altitudes (Maloo et al., 1994), but are of low importance in cooler areas of higher terrain elevation, especially if animals are stall-fed (Deem et al., 1994; Omore et al., 1996a). This therefore means whilst the number of dairy farmers reporting for ECF is high in all Districts (Table 17) the distinction is that in the intensive systems

of the central highland Districts of Maragua, Murang'a, Nairobi and Kirinyaga the figures reflect the farmers' perceived importance of the disease while in the extensive systems in Machakos and Narok it is related to actual incidence (cases) of the disease.

The low percentage reporting for mastitis may be because production is generally low showing that diseases of intensification have not become a serious constraint to milk production. Mastitis therefore is not currently an important constraint to productivity but may be a big problem in future once milk yields are increased. Respiratory problems like calf pneumonias are relatively high in Kirinyaga (9.6%) and Nyandarua (9.5%) probably due to the prevailing cold wet conditions in these Districts. Rampant abortions reported after last heavy rains are being attributed to Rift Valley fever or Lumpy Skin Disease. Moreover, Zoonotic diseases, like Brucellosis, have recently been reported in Mau Narok.

Table 17: Main Diseases Reported (%)

District	ECF	Anaplasmosis	Mastitis	Worms	Respiratory
Maragua	45.8	12.5	12.5	4.2	4.2
Murang'a	20.9	25.6	19.8	4.7	5.8
Kirinyaga	53.8	1.9	1.9	15.4	9.6
Nairobi	75	-	-	-	8.3
Machakos	46.7	6.7	4	9.3	12
Nyandarua	33.3	39.3	2.4	3.6	9.5
Nakuru	55.6	11.6	6.8	6.8	6.3
Narok	73.5	11.8	-	2.9	-
Overall	46.9	16.0	7.0	6.6	7.3

The health management practises, in the last one year, were mainly tick control by 90% of farms (mostly hand sprayed acaricide), use of anthelmintics (92%) and cattle vaccinations by 69%.

3.4.7: Cattle Performance

Since the sample of households surveyed had both dairy and local cattle, it was considered more useful to analyse performance by cattle genotype. For the purpose of this study, two genotypes were identified, and these are dairy and local cattle. Dairy animals include all the exotic breeds of cattle while local animals include the borans and zebus.

For dairy animals, mean age at first calving was 32 (sd 6) months while calving interval and lactation length 519 (sd 160) and 520 (sd 214) days respectively. The prolonged calving intervals may not be due primarily to disease or limited access to reproductive services, but due to the fact that many farmers only consider breeding cows after they have been milked for at least 200 days (Odima *et al.*, 1994) a strategy that maintains cash flow but reduces number of calves produced. Local cows' mean age at first calving is 42.8 (sd 7.7) months, 11 months longer than for dairy cattle. Local cattle's mean calving interval is 510 (sd 148) days, which is closer to that of dairy cattle but their mean lactation length, 639 (sd 234) days is longer than that of dairy cattle.

As shown in Table 18 below the mean milk yield for dairy cattle was 5.9 (sd 4.4) litres while the mean milk yield for local cattle was 2.0 (sd 1.9) litres. The decision by farmers to voluntarily lengthen calving intervals and the low milk yields seem to be linked.

Table 18: Production and Reproductive Performance

District	Breed	Calving Interval (days)	Lactation Length (days)	Milk Prod. (litres)	Age at First Calving (mths.)
Maragua	Dairy	471 (168)	-	6.8 (4.7)	32.9 (3.6)
	Local	-	-	-	-
Murang'a	Dairy	539 (164)	471 (169)	4.7 (3.3)	30.7 (4.9)
	Local	566 (208)	-	3.3 (2.5)	-
Kirinyaga	Dairy	598 (189)	518 (178)	4.7 (3.9)	29.5 (5.3)
	Local	-	-	-	-
Nairobi	Dairy	-	-	7.2 (5.6)	29.6 (7.7)
	Local	-	-	-	-
Machakos	Dairy	575 (239)	-	4.9 (3.8)	33.1 (7.7)
	Local	563 (173)	591 (287)	2.1 (2.2)	40 (7.0)
Nyandarua	Dairy	503 (132)	688 (256)	6.5 (4.9)	30.6 (4.0)
	Local	-	-	-	-
Nakuru	Dairy	491 (152)	423 (159)	6.1 (4.3)	34.1 (7.0)
	Local	-	-	3.2 (2.4)	37.3 (9.5)
Narok	Dairy	-	-	-	-
	Local	489 (132)	687 (175)	1.5 (1.0)	47.3 (3.4)
Overall	Dairy	519 (160)	520 (214)	5.9 (4.4)	32.3 (6.0)
	Local	510 (148)	639 (234)	2.0 (1.9)	42.8 (7.7)

NB/ A dash (-) indicates that n was zero or less than 5 observations.

Milk production, consumption and marketing figures reported were in units of bottles and have been standardised to litres (Table 19). Households on average consumed 2 litres of milk daily. The higher amounts consumed in Nyandarua (2.7 litres) and Narok Districts (2.4 litres) reflects higher home consumption due to the low market access and poor infrastructure while the figure for Nairobi was not reported as they tend to sale all the milk being in the Nairobi milk market. Amounts sold, from all milking cows, varied with the highest being 9 litres in Nyandarua and 7 litres for Nairobi and Nakuru respectively. The other Districts sold on average 4 to 6 litres daily. Prices again reflected market access and depended on the market sales outlets. The highest price per litre was paid in Nairobi and Machakos, Ksh. 26.3 and 22.7 respectively. Other Districts were paid around Ksh. 13 with the exception being Maragua getting Ksh. 11. Payment by all market agents is based on volume and not on composition.

Table 19: Quantities of Milk Consumed by Household, Amounts Sold and Price per Litre

District	Amt. Consumed (litres)	Amt. Sold (litres)	Price per litre (KSh)
Maragua	2.3 (0.8)	6.1 (4.4)	11.1 (1.6)
Murang'a	1.7 (0.8)	3.9 (3.4)	13.0 (2.1)
Kirinyaga	2.2(1.0)	4.6 (4.0)	13.0 (1.6)
Nairobi	-	7.0 (3.4)	26.3 (5.0)
Machakos	1.6 (0.7)	4.5 (6.2)	22.7 (7.9)
Nyandarua	2.7 (1.6)	9.0 (6.3)	13.8 (2.4)
Nakuru	2.2 (1.0)	7.0 (8.0)	12.5 (2.2)
Narok	2.4 (1.0)	4.0 (2.4)	13.6 (1.8)

Another result that reflects low productivity is the rapid declining lactation curve estimated from the survey data. Lactation curves for grade, cross and local cattle were estimated from the data using a semi log-linear function presented below:

$$y = \alpha + \beta_1 \ln x_1 + \beta_2 x_2 + \beta_3 D_C + \beta_4 D_g + \beta_5 INT_C + \beta_6 INT_g$$

Where y is milk yield per day, x_1 is months after calving down, x_2 is parity number, D_c is a dummy variable (1 if cross cattle, 0 otherwise) and D_g is also a dummy variable (I if dairy cattle, 0 otherwise). In this model, the comparison category is the "local cattle" and it allows for the comparison of milk production among cattle of different genotypes. The terms INT_c and INT_g represent the interaction variables between genotype and months after lactation and in the above model, are the slope dummies. Three genotype catagories were identified from the data, and these are local cattle, grade cattle and crosses. The lactation curves was calculated using a combination of reported yields for individual animals including; 1) milk at calving, 2) milk at day of survey, and 3) milk at drying-off (with additional

reporting of calving date and drying-off date). A total number of 2256 observations were used to estimate the specified functional form. Figure 11 shows the estimated lactation curves. As expected, grade cattle outperform crosses and local cattle, although milk yields for all cattle are relatively low.

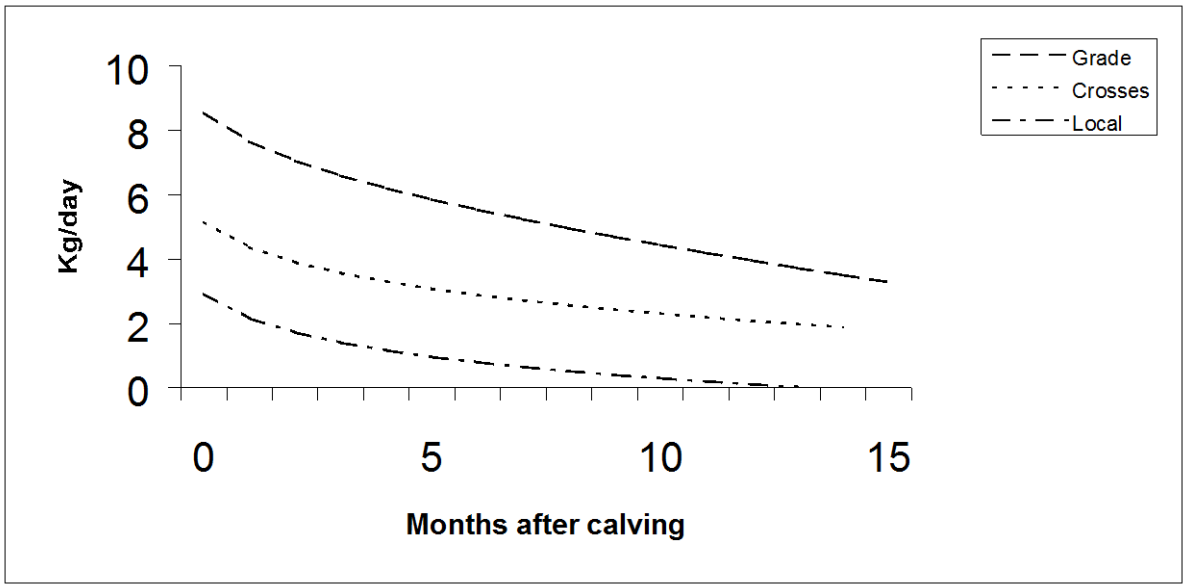

Figure 11: Predicted Lactation Curves for Grade, Local and Cross Cattle

Table 20: Parameter Estimates for Lactation Curves

Yield	Coef.	Std. Err.	t	P>|t|
X_1 (ln_month)	-1.096	.117	-9.358	0.000
X_2 (parity)	.131	.051	2.57	0.010
D_g (grade cattle)	5.75	.250	22.986	0.000
D_c (crosses)	2.254	.460	4.900	0.000
$INTR_g$	-0.50	.022	-6.773	0.000
$INTR_c$	-0.022	.0462	-0.476	0.634
Constant	2.923	.263	11.096	0.000
Adjusted R^2	0.343			

Table 20 summarises the estimation results, and shows the high level of significance in most of the parameter estimates.

3.5 Services and Markets

3.5.1 Input Services

Provision of input services has experienced dramatic changes in the last decade because of policies that support growth of private enterprises (private veterinarians,

para-veterinarians and milk processors) and reduced government support to provision of input services for dairy production. Figure 12 below shows the effective trend in availability (or unavailability thereof) of extension, veterinary and AI services and qualifies whether, if available, they are actually used. The lack of efficient supply of inputs including livestock services is a serious constraint in many areas. Areas in close proximity to Nairobi, dairy co-operatives provide several input services beyond milk marketing, including the bulk supply of animal feed, drugs, AI and veterinary services (Ombui et al., 1995, Owango et al., 1996). Overall 30% of farmers reported availability of AI services from DCS but only half of them use these services preferring also private AI (25%) and GoK AI (10%) where it is still operational.

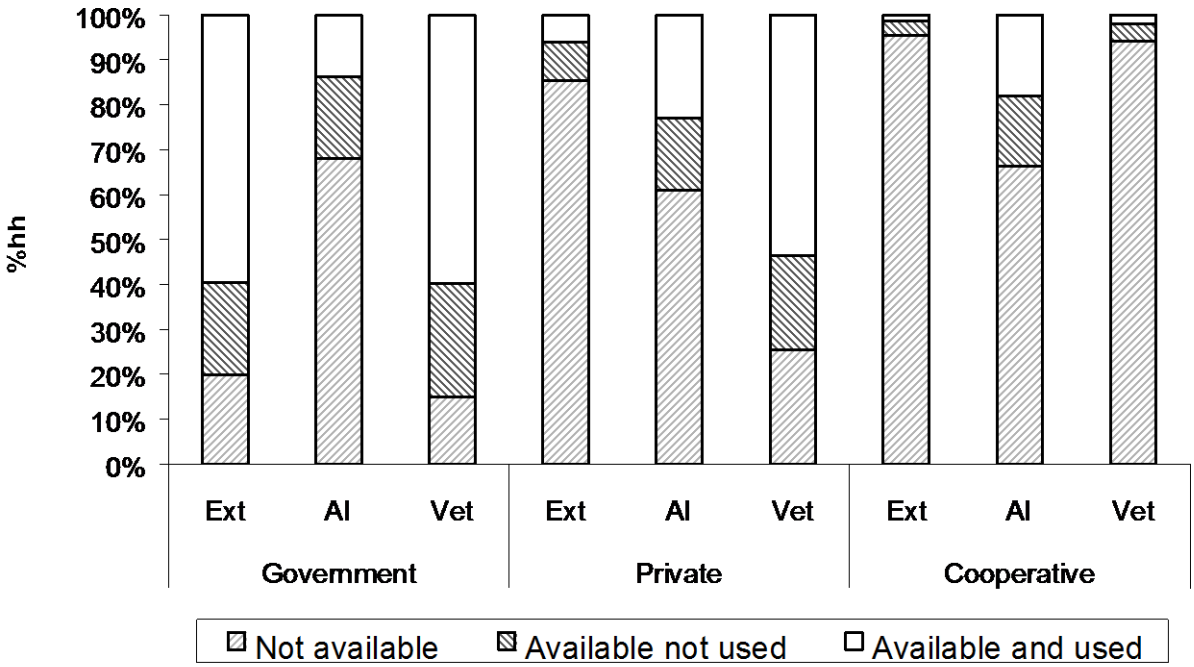

Figure 12: Availability of Input Services By Source: Percent of Dairy Household

Farmers were also asked to indicate the number of extension visits they received in the 12 months preceding the survey. The number of extension services could be taken as an indicator of farmer access to extension. Figure 13 below is a graphical representation of the frequency of extension visits, from all sources (government, private, co-operative etc) in the 12 months period. Apart from Nairobi and Nyandarua districts, all the other districts reported zero extension visits for over 50% of the households surveyed. All Nairobi farmers had at least one extension visit, and they were by far the most well served by extension services. Generally, the result reflects a deficiency in extension services in most of the areas that were surveyed. An important result to note is that despite the liberalisation of extension services, government is still by far the most important source of extension services compared to other sources such as co-operatives, private practitioners and others. Of the extension visits made to farmers, about 84% came from the government,

5% came from private practitioners while the other sources contributed less that 5% each.

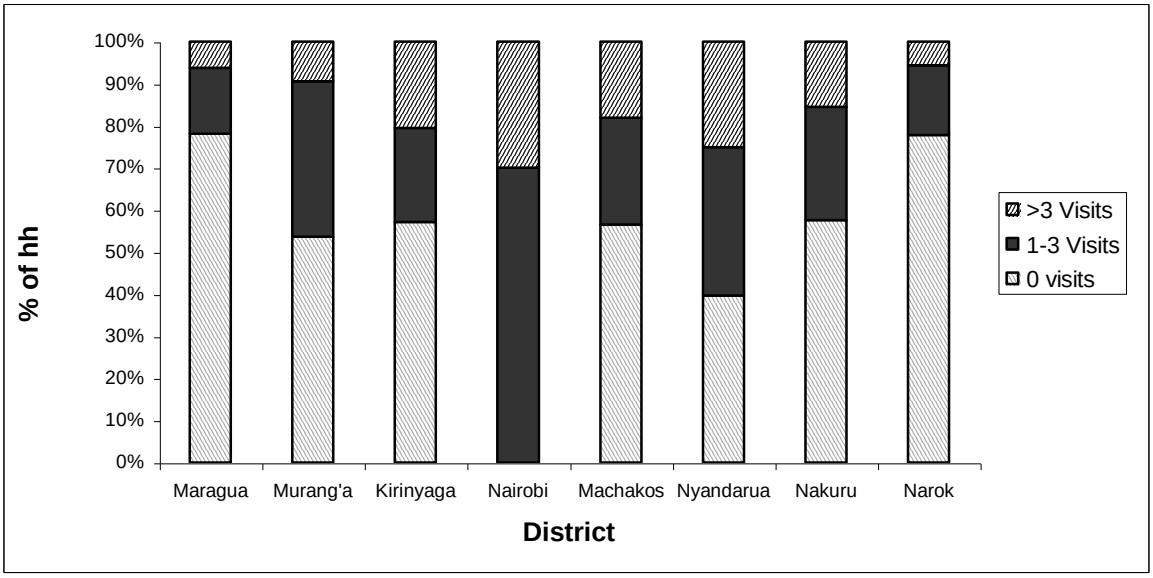

Figure 13: Proportion of households receiving indicated number of extension visits in the last 12 months

3.5.2 Market Access

Nairobi is the major market for farm produce, including perishable commodities such as milk and vegetables, and a source of input services and goods. Table 21 shows how distances to Nairobi varied across the sample, with the furthest farms being in Nakuru District (182 km). Districts in Central Province have relatively better access to the Nairobi market while the ones in the southern Rift have to rely on the emerging market outlets offered by Nakuru. Distances from farm to local market centres, where inputs are generally obtained and where milk collection points are often located, averaged 1 to 6 km. Farmers deliver milk to collection centres in these centres either on-foot or using donkey carts, bicycle, etc.

Table 21: Mean Distances of Farms to Nairobi and to The Nearest Market Centres (Km)

District	Km to Nairobi	Km to Market Centre
Maragua	67.7	1.2
Murang'a	116.2	2.0
Kirinyaga	135.8	1.9
Nairobi	8.3	1.2
Machakos	84.7	2.7
Nyandarua	147.7	3.8
Nakuru	182.5	5.6
Narok	146.1	6.3

3.5.3 Milk Marketing

The marketing of milk has increasingly become decentralised, with greater private sector participation since market liberalisation. Market inaccessibility, caused by poor road infrastructure or long distances, may cause some forced home milk consumption particularly where only morning milk is collected, as was found in parts of Nyandarua, etc. However, it is important to note that even in this milk supply region for Nairobi, the most important market for small farmers is the sale of unprocessed milk to neighbours or in local village markets. There are also numerous informal milk traders and a few formal milk market agents, such as farmer controlled dairy co-operatives and self-help groups, private processors and, to a limited extent, the Kenya Co-operative Creameries (KCC). The overall reported use (% dairy households) of each marketing channel is presented in Figure 14 and show largely sales to individuals (42%), then traders 22%, dairy co-operative societies and groups 12%, hotels and shops 11% and private processors and Kenya Co-operative Creameries each 6%.

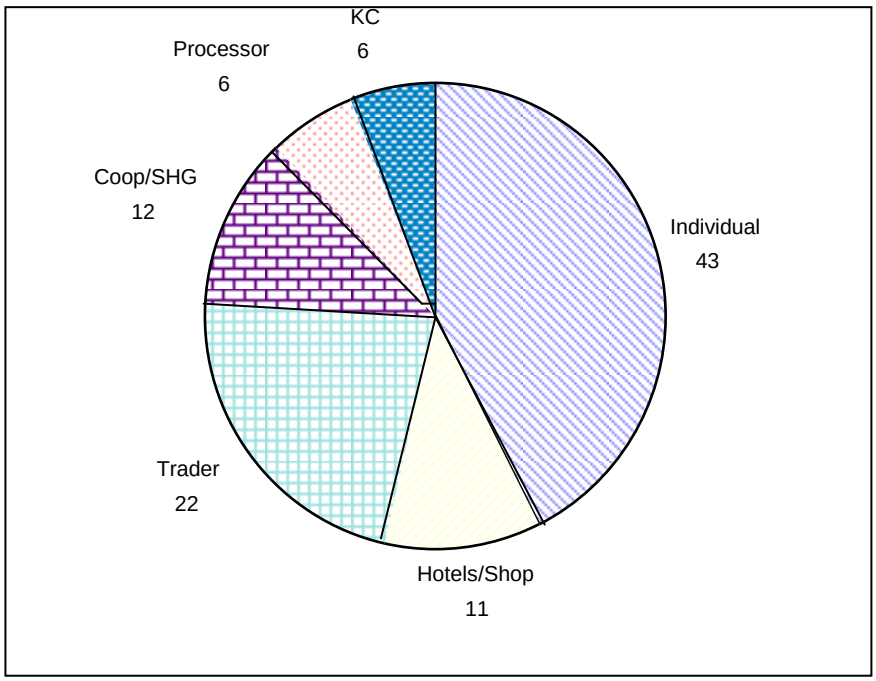

Figure 14: Overall Milk Sales Outlets (% household)

However, the relative importance of the different milk outlets varies widely across the districts surveyed (Figure 15). The areas where farmers sell mainly to an organised channel (coops, private processors and the KCC) include Kiambu (mainly coops), Nyandarua (coops and private processors), and to a lesser extent Murang'a. These tend to be areas where milk surpluses are high, requiring farmers to market milk outside of their locale. In other districts, private traders (hawkers) are important (Nakuru, Murang'a). The reasons for these differences may lie in the local history of institutional development, and remoteness. In milk deficit areas (Machakos, Nairobi and Narok), most milk is sold directly by farmers to neighbours or other consumers. It should be noted that high incidence of direct sales to consumers should not necessarily be interpreted as indicating milk constraints. Rather the opposite is likely to be the case: local sales indicate local milk deficits and strong local demand, so that more organised channels are simply unnecessary.

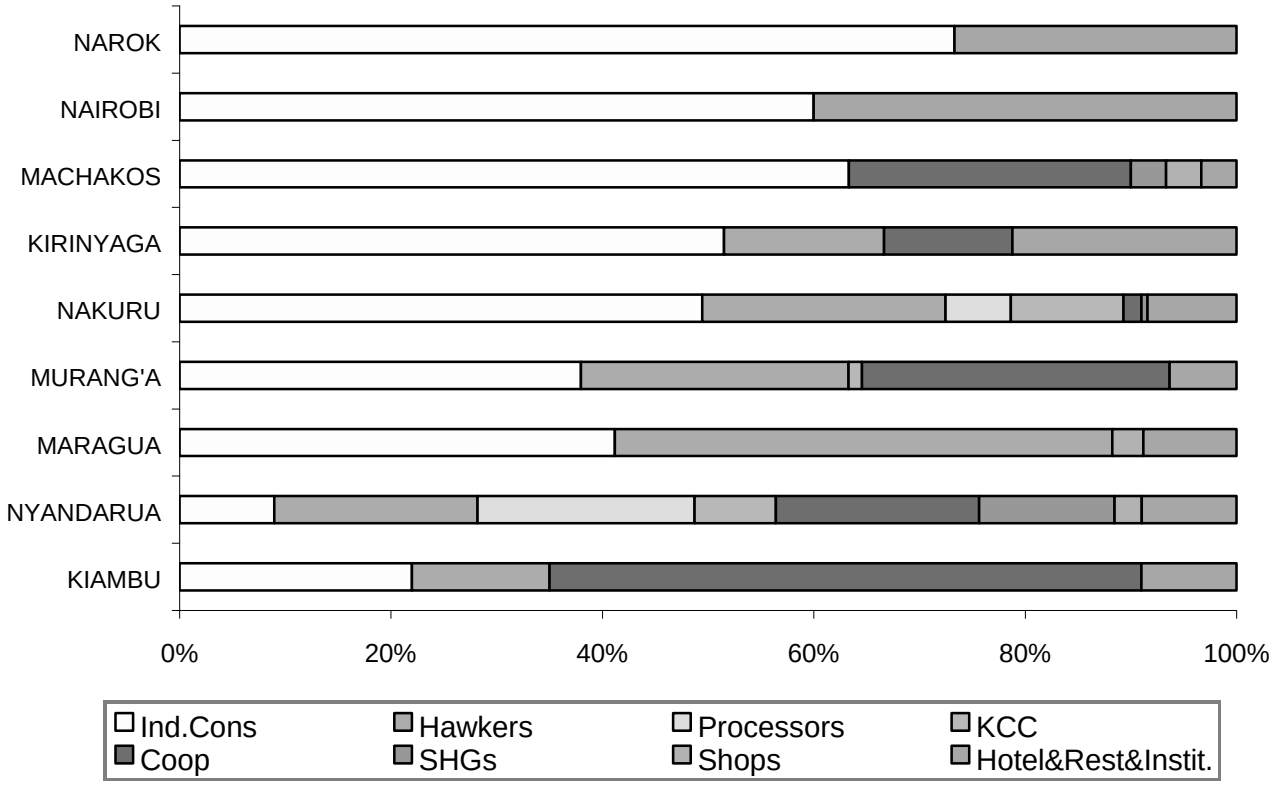

Figure 15: Primary Milk Sales Outlets (% of Farms in Each District)

This interpretation is supported by evidence from milk prices. Milk prices received by farmers varies with the type of outlet used, and are generally highest in the informal outlets such as retail shops, hotels/restaurants, and sales to neighbours (Table 22). Besides type of outlet, another factor that is important in determining producer price of milk is local supply and demand. Farmers living in milk deficit areas like Machakos and Nairobi receive higher prices than those living in milk surplus areas like Nyandarua and Nakuru. Other factors hypothesised to affect producer prices are distance to market, state of the infrastructure and distance to Nairobi among others. Further analysis of this survey data (Staal et al, 1999) has shown conclusively that distance to Nairobi, and quality of roads, have a marked and measurable effect on farm milk prices. They estimate that each additional kilometre of poor feeder road (passable only in the dry season) between a farm and the main road reduced the milk price received by some 35 cents per litre (Ksh 0.35) on the informal market. Poor roads are also likely to affect ability of market agents to operate, reducing their reliability of milk collection. Infrastructure is thus an important determinant not only of returns to smallholder dairy farming, but also of some of the market risks farmers face.

Table 22: Milk Prices Received by Farmers in Central Highlands: I998

Buyer type	Price (KSh/L)	Range
Retail shop	22.50	16.00 - 30.00
Hotel/restaurant/office	17.10	15.10 - 30.00
Individual consumers	16.90	15.10 - 28.30
SHG/Club	15.70	11.00 - 23.50
Private milk trader	14.50	13.80 - 30.00
Private Processor	14.10	16.00 - 25.00
Co-operative	13.60	12.90 - 22.10
KCC	13.20	12.90 - 14.00

Highest prices: Nairobi & Machakos (25 - 30/- per L)
Lowest prices: Nakuru, Muranga, Nyandarua (11-16/- per

3.6 Income

3.6.1 Household Income Categories

Total farm-household cash income (from off-farm sources and farm sales) was reported in six classes. The frequencies for non-agricultural, agricultural and dairy households reporting, within these classes, are shown in Figure 16. These figures do not include household consumption but nevertheless generally indicate levels of household income. The results again show greater representation of dairy households as incomes go up with half of the households in the highest income category (>30,000 Ksh/month) engaged in dairying.

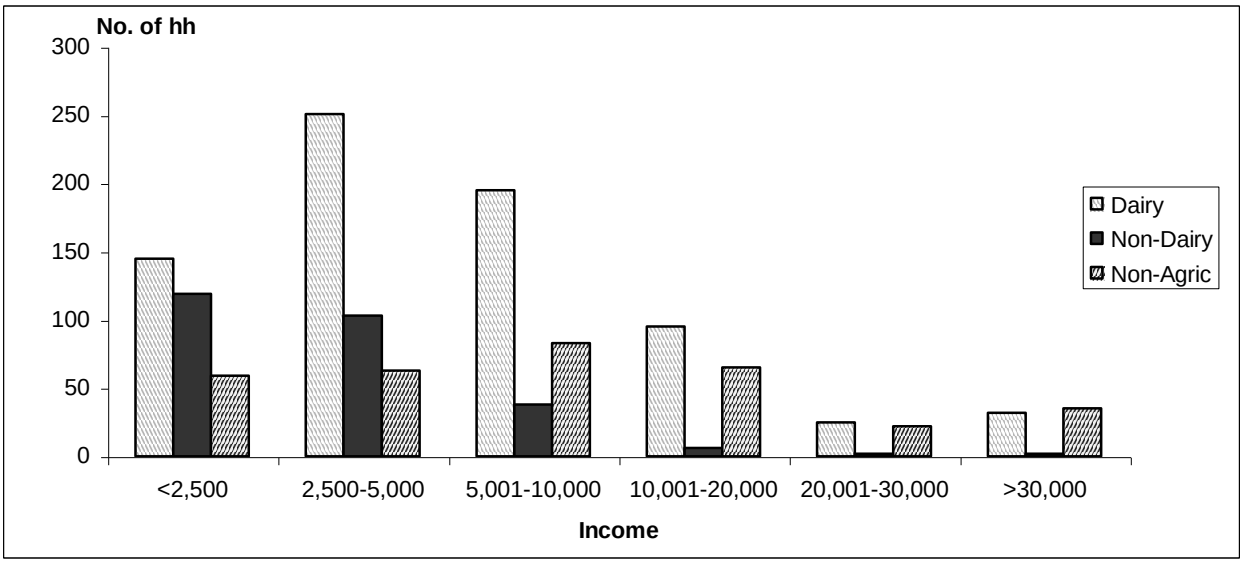

Figure 16: Household Income Categories for Non-agricultural, Agricultural and Dairy Households

The dairy households in most Districts ranked dairy as the main source of farm income. In Maragua 50%, Nairobi 75%, Nyandarua 57% and Nakuru 52% of the households surveyed reported dairy as the main source of farm income. Yet other districts ranked dairy second to sale of cash crops. In Murang'a and Kirinyaga 58 and 76% respectively report sale of coffee as most important while in Narok, 63% ranked sale of wheat as more important than dairy. Machakos has equal ranking, one third each, for dairy, cash and food crops. Overall the findings underline the point that dairy farms generate higher cash incomes and create employment for agricultural households. The net nutrient flows of manure from the dairy animals to cash and food crops has also to be considered, and raises the value of the contribution of dairy production. In a few instances, the value of manure is seen by farmers to be the same as, or greater than, the value of milk especially where milk markets are not reliable.

4. Identifying Target Groups of Dairy Producers for Research and Development Attention

4.1 Background to the Methodology

Developing appropriate interventions to assist smallholder dairy producers, and identifying those which should be targeted requires a clear understanding of the dairy systems. As shown in this study, variation occurs not only in dairy technologies such as feeding strategies, husbandry practices, or breeds of animals, but also in farm/household resource constraints, and the market environment faced by the farm/household. Appropriate interventions should consider all of these factors, and the relationships and patterns among them.

In order to distinguish characteristic patterns of dairy activity existing among the surveyed households, a clustering method was applied to some of the primary variables. The method employs principal component analysis followed by cluster analysis. For a detailed description of the method, see Staal et al (1997) and Gockowski and Baker (1996).

To summarise, the method is motivated by the desire to reduce the number of variables used in the clustering without omitting potentially important information (variation). The principal component method alleviates this constraint by allowing the apparently most important variation from a larger set of variables to be identified and then used to cluster the farm/household observations. Key to application of the method to smallholder dairy producers is the use of a wide range of variables related to dairy production practices, household resources, and market access.

4.2 Selection of Variables Used in Principal Component and Cluster Analysis

The groups of variables used in the principal component analysis were chosen *a priori* on the basis of "themes" considered centrally important not only to the observed heterogeneity among the sample, but also the planned focus of eventual research and interventions.
The themes chosen were:

a. Level of intensification of the farm dairy system,
b. Farm/household resources available, and

c. Level of access to output markets and input services.

As seen from the description of the survey results, there is considerable variation in the level of intensification of dairy activity between farm/households, where intensification is related to the level of purchased inputs per animal and the output of milk per acre of land used. Farm/household resources such as labour and capital may be critical to intensive dairy farming, where dairy requires labour for cut-and-carry feeding and capital for purchases of animals, cattle housing, feed or other inputs.

Market access is also important in this market-oriented system, which the survey showed to produce a large proportion of the milk marketed in Kenya, and where nearly 80% of extracted milk is marketed.

For each theme a set of variables, considered to reflect the primary measures of variability within that theme, was chosen. Table 23 below shows the variables used to indicate the level of intensification of dairy production system, including relative use of maize, napier grass, concentrates, the stocking rate, grazing system and density of milk production.

Table 23: Variables used to Indicate Level of Dairy Intensification

Name	Description	Mean (n=354)	Std dev
MAIZ_CAT	Acreage of maize planted per TLU of dairy cattle	0.59	0.82
NAP_CAT	Acreage of napier planted per TLU of dairy cattle.	0.19	0.42
CONC_CAT	Concentrate feed purchased, in Ksh, per TLU of dairy cattle	1,487	3,257
FODD_CAT	Fodder purchased, in Ksh, per TLU of dairy cattle	491	1,159
LAND_LIV	Total household land in acres per TLU of livestock	2.80	2.90
MILK-ACR	Milk produced per acre	2.16	2.72
COWFEED	Grazing system	2.55	1.15

Similarly, a set of variables was chosen to address the theme of household resources available to the dairy activity and to the farm/household in general. The variables selected as important measures of household resources were female-headedness, off-farm employment by household members, the overall household income level, the total land held by the household and the ratio of dependants (children under 15 and adults over 65 years) to adults in the household. These variables are described in Table 24.

Table 24: Variables used to Indicate Level of Household Resources

Name	Description	Mean (n=354)	Std dev
FEMHEAD	Whether household is female-headed, 1=yes, 0=no	0.22	0.42
OFF_ADT	Proportion of adult (>16yr) hh members who work primarily off-farm.	0.10	0.17
INCOME	Level of total household cash income from all sources, where 1 <2,500 Ksh, 2 is 2,500-5,000, 3 is 5,001-10,000, 4 is 10,001-20,000, 5 is 20,001-30,000, 6 >30,000.	2.77	1.26
TOTLAND	Total acres of land held by household	8.50	13.10
DEPEN_RT	Ratio of dependants to adults	0.41	0.26

Female-headed households were postulated to have poorer access to resources such as formal credit facilities, co-operative services, etc. Off-farm employment of household members affects labour availability for dairying, but may also affect household wealth. Monthly cash income level and total land held were considered indicators of wealth. Dependant ratio may affect household milk consumption, capital liquidity, and availability of household labour.

Finally, a group of variables were selected to measure access of farms to markets. These included distance of the farm to Nairobi, the availability of veterinary services locally (offered mainly by the government and private sector), availability of GoK extension services locally, the farm-gate price of milk received by the farmers, co-operative membership, and milk sales to informal market outlets. The variables are described in Table 25 below. The study shows that government veterinary and extension services were still significant to over half the farmers. Unlike in Kiambu, lack of use of non-governmental outlets is an indicator of lack of market development as a result of low market access, while co-operative membership is not an indicator of access to both input and output markets as most of the cooperatives do not offer any veterinary or extension services. Complete data for the three sets of variables was available from 354 dairy farm/households.

Table 25: Variables Selected as Indicators of Market Access in the Principal Component Analysis and Their Means and Standard Deviations

Name	Description	Mean (n=354)	Std dev
DISTNBI	Distance to Nairobi, in Km	144.89	54.64
VETAVAIL	Availability of veterinary services (1=yes, 0=no)	0.08	0.09
EXTAVAIL	Availability of extension services (1=yes, 0=no)	0.003	0.05
DDFRPRC1	Average price received per litre of milk in most recent dry season Ksh.	13.51	3.31
COOPMEMB	Co-operative membership: 1=yes, 0=no.	0.47	0.50
INFRMKT	Reported milk sales to non-co-operative outlet in last 12 months, 1=yes, 0=no	0.91	0.28

4.3 Cluster Analysis

Cluster analysis was then carried out using the new variables derived through principal component analysis from the variables shown above (see Staal et al, 1998 for a description of the method). The number of clusters was set to different values and the results compared and interpreted for ability to differentiate the observations along the desired axes. Clustering into eight clusters was selected. From these, 4 clusters contain most of the farm/household observations with cluster 1 containing the largest group. Table 26 shows the frequency of households falling under each cluster, and the mean cluster values of a number of descriptive variables from the original survey variable set.

Table 26: Means of Farm/Production, Household and Market/Institutional Participation Characteristics for the Identified Major Dairy Farmer Groups

Cluster	Informal Resource Poor (1)	Intensive Part-time (2)	Extensive Landed (3)	Specialist (4)
Number of households	179	68	67	26
Percent of households*	51	19	19	7
Farm/Production Characteristics				
Farm size (acres)	4.0	4.7	23.3	6.1
Napier acreage	0.2	0.4	0.4	0.6
Maize acreage	0.8	1.0	1.9	1.0
Dairy cattle TLU	1.8	2.3	5.0	2.0
Farm acres per TLU	2.0	1.6	5.0	3.0
Napier acres per TLU	0.1	0.2	0.1	0.4
Concentrate purchased Ksh/TLU/yr	1,300	2,600	1,800	18,700
Fodder purchased Ksh/TLU/yr	390	590	930	6,740
Milk prod./day of calving interval (lts/day)	3.9	3.9	7.0	4.2
Household Characteristics				
Age of household head	50.3	51.3	52.2	48.4
Years dairy experience	17.0	21.2	21.3	21.3
Female hh heads (%)	23	24	20	15
Total household size	6.2	4.5	7.4	5.7
HH adults working off-farm (% of adults)	4	29	5	10
Hh income category	2.1	3.2	3.6	3.4
Market /Institutional Participation Characteristics				
Distance to Nairobi (km)	164	111	134	142
Distance to market (km)	4.6	4.2	6.1	2.5
Co-op membership (%)	34	67	66	69
Availability of vet services (%)	90	100	85	92
Availability of extension (%)	70	80	77	68
Informal milk market participation (%)	99	92	75	78
Multiple market outlets (%)	84	86	63	91
Avg price for milk (Ksh/lt)	12.5	13.8	14.9	14.6
Avg qty of milk sold (lt/day)	2.6	4.3	7.0	5.2

* Some 4% of farms did not fall into these clusters.

Farmers in the largest cluster (1) have the smallest land holdings (4 acres on average), buy very little fodder (less than Ksh 400 per year), have the lowest levels

of total income, and operate mostly through the informal market. They plant only a small amount of land in Napier. Only 34% of them are members of dairy cooperatives, compared with much higher proportions among other farmers. They receive the lowest price for their milk of the 4 groups, which may be related to the fact that they tend to the furthest from Nairobi. Nearly a quarter are female-headed households. Given these characteristics, we will consider these to be the **Informal Resource Poor** (IRP) group of dairy farmers. These farmers comprise some 51% of the dairy farms surveyed, and are thus by far the largest group.

The second largest cluster (2) is composed of farmers with only slightly larger land holdings (4.7 acres), but who grow more Napier and who purchase significantly more concentrate feed and fodder. Milk yields however are as low as those in the IPR group. They tend to be found relatively close to Nairobi, and 66% of them are members of dairy cooperatives. A significant proportion of adults in these households (29%) work off-farm, and 24% of the households are female-headed. These are thus **Intensive Part-time (or Peri-urban) Dairy** farmers (IPD), and make up 19% of the dairy farms surveyed.

Farmers in another cluster of about the same size (3) have large land resources (23 acres) and plant more Napier (0.4 acres), although they also purchase fodder and concentrates. Possibly as a result of these land resources, they exhibit the highest milk yields, at 7 l/day of lactation. They have higher income levels than the other farmers, and tend to rely on dairy cooperatives to market their milk. They can be called the **Extensive Landed Dairy** farmers (ELD).

The last significant group is distinguished primarily by the very large amounts of concentrate feed and fodder they purchase, as well as larger areas of Napier planted (0.4 acres per TLU). More than 90 % of them also rely on multiple market outlets to sell their milk. These are characteristics of specialization in dairy production, and so this group can therefore be called **Specialised Dairy** (SD) producers. The milk yields they obtain remain relatively low, however, at 4.2 liters per day. They comprise a small group within the dairy farmers at less than 10% of the total.

Table 27: Number of Observations and Percentages per Cluster by Agro-climatic Potential and Market Access

Agro-climate potential	High		Medium		
Market access	Medium	Low	High	Medium	Low
Cluster (% of total in row)					
Inf Resource poor	37 (19%)	34 (20%)	- (0%)	107 (60%)	1 (1%)
Intensive part-time	44 (65%)	5 (7%)	6 (7%)	13 (19%)	- (0%)
Extensive landed	5 (7%)	30 (45%)	8 (12%)	18 (27%)	6 (9%)
Specialist	12 (46%)	5 (19%)	3 (12%)	6 (23%)	- (0%)

Table 27 shows where the clusters of households fall according to the 2 criteria used to initially stratify the survey: agro-climatic potential and market access. These criteria were assigned to the survey districts based on expert informant opinion. The Informal Resource Poor are clearly found mainly (60%) in areas with relatively-low (medium) agro-climatic potential, and medium market access (note that in this survey area, medium represents the lowest level of agro-climatic potential). It is thus apparent that relatively low levels of these factors are related to the combination of traits found in this group of farmers: low incomes, low access to services, and small land-holdings. A significant proportion of IPR farms are also found in high agro-climatic potential zones, equally divided between market access levels there. Intensive Part-Time dairy farmers are found mainly (65%) in areas of both high productive potential and good market access, in line with the peri-urban nature of their activity in zones close to Nairobi with high rainfall. The Specialists are in the same zones, and may simply represent a more intensive form of peri-urban dairy production. Extensive Landed dairy farmers are mainly in areas of lower market access, with 45% of them in areas where productive potential is also high. The results in Table 27 show clear patterns of farm type and intensification strategy in different combinations of two of the main determining factors.

4.4 Selection of Target Farmers

Based on the above analysis, and given the project goal of poverty alleviation, the Informal Resource Poor group of dairy farmers may be the appropriate target group for further research and development efforts. The constraints they face go beyond landholding and resource poverty to include access to services, markets and information. They also represent a majority of dairy farms in the survey area, and thus positive interventions among this group offer the potential for substantial impact.

5. Conclusions

The survey showed that in the districts where land sizes are small and land is thus a constraint, farmers have incentive to intensify and the main system of keeping cattle is "stall feeding". Thus even though extensive grazing is still practised in districts where the land holdings are large, the continued subdivision of the land in successive generations mean that in future, intensive grazing may be the predominant system for keeping cattle. This trend is reflected in the higher level reported by the surveyed farmers of zero grazing now compared to 10 years ago, a relatively short period. Future planning of dairy development efforts, and technology delivery efforts, should keep these strong trends in sight. It is unclear, however, what the long-term competitiveness of these different production systems will be, but with current low opportunity costs for labour, the advantage is apparently with more intensification. Analysis of labour allocation to dairy indicate that males contribute 36% and females 24% of the dairy labour, and the rest is provided by children and hired labourers. This result is significant because it appears to contradict an important hypothesis that labour associated with intensification of smallholder dairying is mostly shouldered by the women of the household (Rey et al, 1993). However, preliminary results from the longitudinal surveys in Kiambu, Nakuru and Nyandarua corroborate the conclusion from this characterisation survey. Given these heavy labour demands of intensive dairy production, any increase in labour costs due, for example, to general economic development, could swing the advantage towards more extensive production. Some analysis of these trade-offs has been conducted by Baltenweck et al (1999) using this same survey data.

The two predominant breeds of cattle are Friesian and Ayrshire, reported in 42% and 18% of the farms respectively. There is a definite preponderance for these bigger breeds and a disregard for smaller breeds such as Guernsey and Jersey. There is evidence from the survey of under-nutrition in livestock. Estimates from the survey results show that zero-grazed dairy cattle each get about 47 kg of fodder per day, which is lower than the recommended 60 to 70 (approximately 10 to 15 DM) Kg per day. The problem of under-nutrition may largely be explained by shortage of fodder due mainly to small land holdings relative to the number of animals, although concentrates are also fed at relatively low levels, about 1 kg per zero-grazed milking cow per day, and much less for the grazed cattle. Partly as a consequence, productivity indicators are also low. The mean age at first calving for the high-grade animals is 32 months, the mean calving interval is 519 days and the mean milk yield is 5.9 litres per day. However, the low levels of feeding may yield optimal overall returns to farmers, given their aversion to risk-taking. Previous research in Kiambu (Wachira et al, 1997) has shown that the increased risks from higher investment in fodder production and purchase of concentrates may outweigh the increased returns for many farmers. Interventions to improve the levels of nutrition should therefore consider farmer resources, and not require significant increases in exposure to market and climatic risk through greater cash expenditure or reallocation of crop land. Herbaceous or tree fodder legumes that compete less with crops may be options. Shifting of concentrate feeding to the first half of the lactation to raise milk yields per lactation, without significantly increasing overall purchases, has also been proposed.

Production systems in dairy farming in Kenya display a wide variability of strategies, each of it responding to the particular marketing and environmental conditions present in the area. The longer-term competitiveness of these systems changes over time, depending in land values, market and institutional infrastructure. The results show that organised marketing channels are still mainly predominant in areas closer to the Nairobi milk shed, while in more distant areas, direct sales to consumers and traders prevail. If road and market infrastructure were to improve then organised marketing is likely to better reach distant areas, enabling high milk prices to those producers. Under those circumstances, the competitiveness of production is likely to shift significantly.

Important implications from the findings can be drawn in four key areas: a) intensification of smallholder systems; b) constraints to dairy productivity; c) access to services; and, d) identification of target groups.

The results point clearly to the rapid intensification of smallholder dairy production, which is occurring in the central part of Kenya apparently as a result mainly of shrinking land holdings. Over the last ten years farms have shifted increasingly to the use of stall-feeding and to planting of fodder, and now rely less on natural fodder. Also clear, however, are the wide differences in levels of intensification across the area depending on agro-climate and market access. The main implication is that while improved technologies for sustained intensification are needed, they cannot be applied uniformly. Blanket recommendations for intensive production strategies should be avoided. A difficult challenge may be to assist the appropriate intensification of farms in those outlying areas where many of the resource poor farmers are found, which do not have high agro-ecological potential, yet which need to improve productivity due to shrinking land holdings.

Constraints to dairy productivity continue to centre around inadequate and seasonal feed resources. Solutions to these problems will have to keep in mind the limitations to opportunities for intensification outlined above. For example the use of planted grass fodders for stall-feeding may be limited in extensive areas where labour rather than land is the limiting constraint.

Threats to productivity over the long term may be posed by the constraints to selective breeding. AI services continue to be used by only a relatively small proportion of farmers and the long-term trends in herd genotype are unclear. Private veterinary services of indeterminate quality are now available to most farms across the area. Few cooperatives offer breeding or vet services. Perhaps surprisingly, most farms report continued contact with government extension services. The status of access to services is thus mixed with apparently successful private sector entry into vet services, but less success in the private provision of AI services. However, these services are used mostly by the more privileged or advanced dairy farmers.

The cluster analysis shows that about half the dairy farms in central Kenya remain resource-poor with small land holdings and located far from formal market services and urban areas. Improving the sustained productivity and profitability of this large majority group of farms and households will be key to success in rural development, poverty reduction and environmental protection in the region.

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Appendix 1 Number of Households to Sample in Each District by Land-Use System

a. Sheep/Dairy Land-use System

District	Division	Sub-location	LUZ	Households	
				census	sample
Murang'a	Kangema	Ichichi	sheep/dairy	3,346	22
Nakuru	Molo	Keringeti	sheep/dairy	14,397	13
Nakuru	Njoro	Likia/Teret	sheep/dairy	18,059	20
Nakuru	Molo	Kiambiriria	sheep/dairy	13,187	14
Nakuru	Bahati	Kabatini	sheep/dairy	9,079	50
Narok	Mau	Ntulele	sheep/dairy	7,546	10
Nyandarua	Ol-Kalou	Ruiru	sheep/dairy	3,462	10
Nyandarua	Kinangop	Gathara	sheep/dairy	6,094	10
Nyandarua	Kinangop	Kahuru/Muruaki	sheep/dairy	10,540	10
Nyandarua	Kinangop	Bamboo	sheep/dairy	5,706	10
Nyandarua	Ol-Kalou	Melangine	sheep/dairy	6,951	10
Nyandarua	Kinangop	Gitwe	sheep/dairy	3,546	19
				101,913	203

b. Tea/Dairy Land-use System

District	Division	Sub-location	LUZ	Households	
				census	sample
Kirinyaga	Gichugu	Ngiriambu	tea/dairy	4,914	10
Kirinyaga	Gichugu	Thirikwa	tea/dairy	3,519	10
Kirinyaga	Gichugu	Nyangeni	tea/dairy	4,438	10
Kirinyaga	Gichugu	Kariru	tea/dairy	3,673	10
Kirinyaga	Ndia	Nguguine	tea/dairy	5,685	12
Murang'a	Kangema	Gacharageini	tea/dairy	6,288	14
Murang'a	Kangema	Kairo	tea/dairy	2,850	10
Murang'a	Kangema	Gikui	tea/dairy	9,008	19
Murang'a	Kiharu	Kahuro	tea/dairy	8,733	35
Murang'a	Kiharu	Kahuti	tea/dairy	5,629	22
Murang'a	Kandara	Mungaria	tea/dairy	9,043	30
				63,780	180

c. Coffee/Dairy Land-use System

District	Division	Sub-location	LUZ	Households	
				census	sample
Kirinyaga	Ndia	Gitaku	coffee/dairy	6,196	10
Kirinyaga	Gichugu	Mirichi	coffee/dairy	5,689	10
Kirinyaga	Ndia	Mukui	coffee/dairy	3,212	10
Kirinyaga	Ndia	Kagumo	coffee/dairy	2,187	10
Machakos	Kangundo	Kiboko	coffee/dairy	15,383	16
Machakos	Mwala	Vyulya	coffee/dairy	8,479	10
Machakos	Kangundo	Isinga	coffee/dairy	8,794	10
Murang'a	Kiharu	Kimathi	coffee/dairy	6,523	10
Murang'a	Kangema	Nyakahura	coffee/dairy	3,920	10
Murang'a	Kangema	Gacharaigu	coffee/dairy	5,005	10
Murang'a	Kiharu	Gatheru	coffee/dairy	5,979	10
Murang'a	Kiharu	Kiria	coffee/dairy	9,491	16
Murang'a	Kandara	Kariua	coffee/dairy	7,512	12
Murang'a	Kandara	Githunguri	coffee/dairy	10,359	16
Murang'a	Kandara	Githuya	coffee/dairy	1,975	14
Murang'a	Kandara	Kagundu/Kariti	coffee/dairy	10,853	17
Nakuru	Molo	Ndoswa	coffee/dairy	494	10
Nakuru	Molo	Marioshoni	coffee/dairy	2,298	10
Nakuru	Njoro	Siapei	coffee/dairy	14,652	19
Nakuru	Rongai	Lenginet	coffee/dairy	21,001	26
Nakuru	Bahati	Wendo	coffee/dairy	6,235	10
Nakuru	Bahati	Dundori	coffee/dairy	21,813	30
Nyandarua	Ol-Kalou	Kanjuiri	coffee/dairy	4,062	10
Nyandarua	Ol-Kalou	Rurii	coffee/dairy	5,980	10
Nyandarua	Kinangop	Karati	coffee/dairy	5,026	10
				193,118	311

d. Horticulture/Dairy Land-use System

District	Division	Sub-location	LUZ	Households	
				census	sample
Kirinyaga	Ndia	Kianjege	hort/dairy	3,685	12
Machakos	Mwala	Kithangaini	hort/dairy	5,015	10
Machakos	Mwala	Utithini	hort/dairy	4,391	10
Machakos	Mwala	Kamwala	hort/dairy	4,065	10
Machakos	Mwala	Mithini	hort/dairy	4,447	12
Machakos	Kangundo	Iia-Itune	hort/dairy	3,956	12
Machakos	Kangundo	Sengani	hort/dairy	6,975	19
Machakos	Kangundo	Kambusu	hort/dairy	6,744	19
Murang'a	Kiharu	Nyakihai	hort/dairy	5,487	17
Nakuru	Rongai	Kampi Ya Moto	hort/dairy	6,182	10
Nakuru	Bahati	Kirima	hort/dairy	6,209	10
Nakuru	Njoro	Ngata	hort/dairy	12,188	14
Nakuru	Rongai	Banita	hort/dairy	21,068	36
Narok	Mau	Olopito	hort/dairy	5,708	12
Narok	Mau	Enaibor Ajijik	hort/dairy	2,371	10
				98,491	212

e. Wheat/Dairy land-use System

District	Division	Sub-location	LUZ	Households	
				census	sample
Nakuru	Rongai	Ol-Rongai	wheat/dairy	14,335	29
Nakuru	Rongai	Shawa	wheat/dairy	8,978	17
Nakuru	Bahati	Munanda	wheat/dairy	7,400	13
Nakuru	Njoro	Nessuit	wheat/dairy	11,174	13
Nakuru	Molo	Turi	wheat/dairy	12,757	14
Nakuru	Njoro	Njoro	wheat/dairy	22,025	29
Narok	Mau	Sakutiek**	wheat/dairy	12,357	12
Narok	Mau	Township	wheat/dairy	24,574	33
Nyandarua	Ol-Kalou	Mawingo	wheat/dairy	3,064	10
				116,664	172

f. Urban System

District	Division	Sub-location	LUZ	Households	
				census	sample
Nairobi	Kasarani	Roysambu	Urban	13,528	11
Nairobi	Kasarani	Kasarani	Urban	11,711	10
Nairobi	Kibera	Mugumoini	Urban	7,975	10
Nairobi	Kasarani	Kahawa North	Urban	23,567	14
Nairobi	Kibera	Woodley	Urban	7,411	10
Nairobi	Kibera	Nairobi West	Urban	26,080	16
Nairobi	Kibera	Golf Course	Urban	7,977	10
Nairobi	Kasarani	Ruaraka	Urban	55,821	53
Nairobi	Kasarani	Mathare	Urban	47,722	48
Nairobi	Kibera	Kibera	Urban	122,643	113
				324,435	312

Appendix 2 Summary Tabular Results By Land-Use Systems

Number and % of Households Surveyed, Agricultural and Dairy Household by Land-Use Zone.

LUZ	No. HH	Agricultural		Dairy	
		N	%	N	%
Sheep/dairy	203	195	97.50	134	66.00
Tea/dairy	180	173	97.70	136	75.60
Coffee/dairy	311	290	98.00	223	71.70
Hort./dairy	212	182	89.20	125	59.00
Wheat/dairy	172	138	80.70	99	57.60
Urban	312	37	13.50	23	7.40
Total/Av.	1390	1015	79.43	740	56.22

Household Head Characteristics

LUZ	Sex (%)		Education level (%)				Farm mgt. (%)	Age
			None	Pri.	Sec.	Post Sec.		
	Male	Female						
Sheep/dairy	66.5	33.50	17.4	55.3	22.60	4.70	71.40	47.0 (14.3)
Tea/dairy	75.1	24.90	8.5	55.4	27.10	9.00	70.10	49.4 (13.0)
Coffe/dairy	77.6	22.40	16.1	54.8	21.70	7.40	65.90	52.2 (15.2)
Hort./dairy	72.0	28.00	15.8	49.8	29.60	4.90	71.40	48.6 (15.1)
Wheat/dairy	80.8	19.20	15.2	45.7	27.40	11.60	49.40	48.7 (15.1)
Urban	79.7	20.30	3.2	29.4	39.40	28.10	9.10	38.4 (14.6)
Overall av.	75.3	24.72	12.7	48.4	27.97	10.95	56.22	47.0 (15.4)

Household Sizes and Composition

LUZ	Number in each Age Category and (sd)					
	< 8	8-14	15-22	23-65	>65	Av. no.
Sheep/dairy	1.4 (!.5)	1.3 (1.5)	1.0 (1.2)	2.2 (2.0)	0.1 (0.4)	6.0 (3.6)
Tea/dairy	0.8 (1.1)	1.3 (1.3)	1.0 (1.8)	2.0 (1.0)	0.2 (0.5)	5.3 (3.0)
Coffee/dairy	1.2 (1.7)	1.0 (1.2)	1.0 (1.4)	2.2 (1.6)	0.3 (0.7)	5.7 (3.2)
Hort./dairy	1.6 (1.6)	1.1 (1.3)	1.0 (1.3)	2.3 (1.3)	0.3 (0.6)	6.3 (3.1)
Wheat/dairy	1.4 (1.4)	1.1 (1.4)	1.1 (1.5)	2.5 (1.6)	0.2 (0.5)	6.2 (3.5)
Urban	1.1 (1.1)	0.7 (1.1)	0.9 (1.0)	2.3 (1.7)	0.1 (0.3)	5.1 (2.8)
Average	1.2 (1.5)	1.1 (1.3)	1.0 (1.4)	2.2 (1.6)	0.2 (0.5)	5.7 (3.2)

Average Land Holding Size, Number of Plots, Years since it's Establishment.

LUZ	n	Total land (acres)	No. plots	Years est.	Acreage same as at est. (%)
Sheep/dairy	200	8.2 (15.0)	1.4 (1.3)	16.5 (10.0)	76.3
Tea/dairy	178	2.8 (3.1)	2.0 (8.2)	21.1 (12.0)	78.0
Coffee/dairy	307	5.2 (8.0)	1.7 (4.8)	20.0 (12.4)	77.5
Hort./dairy	185	9.4 (15.5)	2.0 (4.8)	22.1 (13.2)	68.4
Wheat/dairy	138	7.7 (10.6)	1.9 (8.0)	14.8 (6.9)	82.4
Urban	36	8.8 (22.0)	1.9 (1.8)	11.0 (8.3)	83.3
Total/Av.	1044	6.6 (11.9)	1.8 (5.4)	18.9 (11.7)	77.7

Cropping Seasons, Acreage of Main Food/Cash Crops

LUZ	Cropping Season (%)		Acreage of Crops (sd)					
	One	Two	No HH	Coffee	Tea	Napier	Maize	Beans
Sheep/dairy	22.5	74.5	195	0.0 (0)	0.2 (0.7)	0.2 (0.6)	0.9 (1.6)	0.3 (0.5)
Tea/dairy	0	100	173	0.6 (0.9)	0.2 (0.6)	0.4 (0.6)	0.6 (1.0)	0.2 (0.6)
Coffee/dairy	12.9	87.1	290	0.3 (0.7)	0.0 (0.1)	0.2 (0.6)	0.8 (1.3)	0.7 (1.2)
Hort./dairy	22.5	77.5	182	0.5 (1.3)	0.0 (0)	0.2 (0.9)	1.0 (1.2)	0.8 (0.9)
Wheat/dairy	45.5	54.6	138	0.0 (0)	0.0 (0)	0.1 (0.4)	1.4 (2.6)	1.1 (2.5)
Urban	42.9	57.1	37	0.0 (0)	0.0 (0)	1.2 (7.1)	0.8 (2.1)	0.5 (1.1)
Average			1015	0.3 (0.8)	0.1 (0.4)	0.3 (1.5)	0.9 (1.6)	0.6 (1.3)

Numbers of Livestock Other Than Cattle

LUZ	Goats		Sheep	Poultry			Pigs	Donkeys
	Local	Dairy		Local	Layers	Broilers		
Urban	111	0	128	265	200	1045	138	2
Coffee/Dairy	219	15	462	1864	411	300	27	34
Hort/Dairy	809	32	504	1266	0	0	27	73
Sheep/Dairy	145	2	801	1303	12	0	18	46
Tea/Dairy	124	16	48	787	1323	10	60	0
Wheat/Dairy	294	38	674	1671	247	33	54	28
TOTALS	1702	103	2617	7156	2193	1388	324	183

Cattle Inventory and Mean Numbers/(sd)

LUZ	Local		Crosses		Grade	
	n	Mean (sd)	n	Mean (sd)	n	Mean (sd)
Sheep/dairy	12	6.7 (6.2)	46	6.5 97.4)	73	5.0 (4.8)
Tea/dairy	3	1.3 (1.5)	46	2.3 (1.50	91	2.0 (1.4)
Coffee/dairy	25	3.0 (2.8)	69	3.0 (2.8)	132	2.6 (1.8)
Hort./dairy	77	8.0 (11.0)	31	2.4 (1.7)	27	3.2 (2.2)
Wheat/dairy	10	11.1 (10.9)	61	4.6 (4.0)	32	5.4 (6.1)
Urban	2	4.0 (2.8)	6	4.5 (4.5)	12	11.3 (19.9)
Average	129	6.9 (9.6)	259	3.8 (4.3)	367	3.5 (5.0)

Main feeding System Practised (%) by Land use Zone - Now/Ago

LUZ	Grazing	Semi Zero	Stall Feeding
Sheep/dairy	28.3 /34.1	55.8/47.1	20.9/18.7
Tea/dairy	6.2/18.7	23.1/19.5	70.8/61.8
Coffee/dairy	17.3/27/8	39.6/32.2	43.2/39.5
Hort./dairy	47.1/57.8	23.5/24.5	29.4/17.6
Wheat/dairy	40.4/73.6	50.5/23.1	9.1/3.3
Urban	35.0/69.2	25.0/23.1	40.0/7.7
Overall	25.0/39.1	38.0/30.0	37.1/30.7

Predominant Dairy Breeds in the Herds (%)

LUZ	Friesian	Ayrshire	Jersey	Guernsey	Bos Indicus
Sheep/dairy	56.7	23.6	2.4	10.2	7.1
Tea/dairy	47.5	23.3	4.2	19.2	5.8
Coffee/dairy	38.4	18.5	3.2	17.1	27.8
Hort./dairy	19.8	6.0	0.9	5.2	68.1
Wheat/dairy	4.2	21.1	5.3	3.2	26.3
Urban	60.0	15.0	0.0	20.0	5.0
Overall	41.6	18.4	3.0	12.4	24.6

Production Performance

LUZ	Calving Interval (days)	Lactation Length (days)	Milk Prod. (litres)	Age at First Calving (mths.)
Sheep/dairy	494.3 (122.9)	522.0 (246.3)	4.8 (3.00	31.9 (4.6)
Tea/dairy	594.5 (245.3)	560.2 (322.6)	5.0 92.5)	30.6 (5.7)
Coffee/dairy	551.8 (191.6)	652.0 (378.0)	4.4 92.3)	32.9 (7.3)
Hort./dairy	608.6 (285.7)	510.2 (290.4)	2.7 (2.6)	37.5 97.5)
Wheat/dairy	551.7 (262.5)	434.3 (165.0)	4.6 (2.7)	32.3 (6.30
Urban	502.4 (175.1)	660.0 (337.5)	6.3 (5.6)	30.5 (7.2)
Overall	559.5 (223.4)	559.8 9314.7)	4.4 (2.8)	32.9 (6.9)

Breeding and Source of Service (%)

LUZ	Pregnancy rate	Source of service				
		Bull	GOK	Coop.	Private	Others
Sheep/dairy	51.5	82.0	1.9	9.4	6.6	0.0
Tea/dairy	43.6	59.5	8.9	15.8	14.9	0.0
Coffee/dairy	46.9	68.0	7.8	9.8	14.4	2.2
Hort./dairy	48.0	87.8	1.7	1.7	6.6	0.0
Wheat/dairy	51.6	63.1	10.3	3.4	23.2	0.0
Urban	51.7	29.7	2.7	0.0	67.6	0.0
Overall	48.8	71.4	5.8	7.2	14.6	0.7

Quantities of Milk Consumed by HOUSEHOLD, Amounts Sold and Price per Litre

LUZ	Amt. Consumed (litres)	Amt. Sold (litres)	Price per litre (KSh)
Sheep/dairy	2.3 (1.4)	8.7 (7.6)	13.1 (1.9)
Tea/dairy	2.2 (1.0)	5.0 (4.1)	12.5 (2.1)
Coffee/dairy	2.3 91.1)	5.1 94.7)	13.3 (4.1)
Hort./dairy	2.1 (1.0)	5.1 (5.4)	16.2 (7.1)
Wheat/dairy	2.1 (1.1)	7.5 (9.0)	13.0 (2.4)
Urban	1.9 (0.4)	5.9 (3.2)	21.5 98.1)
Overall	2.2 (1.1)	6.3 (6.5)	13.7 (4.3)

Primary Milk Sales Outlets (%)

LUZ	Individuals	Hotels/ Shops	Traders	Coop/SHG.	Processors	KCC
Sheep/dairy	20.0	13.7	17.9	20.0	10.5	17.9
Tea/dairy	41.2	13.2	23.5	22.1	-	-
Coffee/dairy	48.3	8.2	23.1	14.3	2.7	3.4
Hort./dairy	69.2	7.7	5.8	17.3	-	-
Wheat/dairy	38.6	7.8	34.9	-	15.7	3.6
Urban	46.7	40.0	-	6.7	-	6.7
Overall	42.0	10.5	21.5	14.1	5.9	5.7

Main Diseases Reported (%)

LUZ	ECF	Anaplasmosis	Mastitis	Worms	Respiratory
Sheep/dairy	29.6	32.4	5.6	8.3	9.3
Tea/dairy	24.4	21.8	11.5	10.3	5.1
Coffee/dairy	52.9	13.4	7.6	6.4	7.6
Hort./dairy	59.4	6.6	4.7	3.8	8.5
Wheat/dairy	57.6	9.8	6.5	5.4	5.4
Urban	61.1	5.6	5.6	5.6	5.6
Overall	46.9	16.0	7.0	6.6	7.3

Appendix 3 Summary Tabular Results by Production Potential and Market Access

Number and % of Total Households Surveyed, Total Agricultural and Dairy Households by Potentiality.

Potential	No. HH	Agricultural		Dairy	
		n	%	n	%
High - Low	110	110	100	98	89.1
High - Med	371	364	98.1	284	76.5
Med - High	378	146	38.6	92	24.3
Med – Low	78	42	53.8	36	46.2
Med - Med	381	351	92.1	230	60.4
Total/Av.	1318	1013	76.5	740	59.3

Household Head Characteristics

Potential	Sex (%)		Education level (%)				Farm mgt. (%)	Age
			None	Pri.	Sec.	Post-Sec.		
	Male	Female						
High - Low	76.1	23.9	10.4	58.5	23.6	5.8	76.1	
High - Med	74.7	25.3	10.2	53.9	28.2	7.0	68.9	
Med - High	72.5	27.5	7.0	33.7	36.1	20.6	22.8	
Med – Low	88.6	11.4	16.2	35.1	37.8	10.9	30.4	
Med - Med	77.5	22.5	19.6	54.8	20.2	5.1	58.2	
Total/Av.	77.9	22.1	12.7	47.2	29.2	9.9	51.3	

Household Sizes and Composition

Potential	Number in each Age Category and (sd)					
	< 8	8-14	15-22	23-65	>65	Av. no.
High - Low	1.6 (1.7)	1.2 (1.3)	0.9 (1.4)	2.5 (2.7)	0.2 (0.5)	6.4 (4.0)
High - Med	0.8 (1.1)	1.1 (1.3)	0.8 (1.4)	1.9 (1.1)	0.3 (0.6)	4.9 (2.8)
Med - High	1.3 (1.4)	0.9 (1.1)	1.0 (1.0)	2.4 (1.6)	0.2 (0.5)	5.6 (3.0)
Med – Low	2.0 (1.7)	1.1 (1.3)	1.0 (1.4)	2.2 (1.0)	0.1 (0.2)	6.2 (3.7)
Med - Med	1.4 (1.6)	1.2 (1.4)	1.2 (1.5)	2.4 (1.6)	0.2 (0.5)	6.3 (3.3)
Average	1.2 (1.5)	1.1 (1.3)	1.0 (1.4)	2.2 (1.6)	0.2 (0.5)	5.7 (3.2)

Average Land Holding Size, Number of Plots, Years Since it's Establishment.

Potential	n	Total land (acres)	No. plots	Years est.	Acreage same as at est. (%)
High - Low	113	13.4 (15.0)	1.7 (1.2)	16.8 (11.8)	62.8
High - Med	379	3.3 (4.0)	1.8 (6.4)	22.2 (12.2)	75.1
Med - High	150	9.1 (13.0)	2.0 (1.2)	24.2 (14.8)	68.5
Med - Low	43	18.8 (23.5)	1.6 (0.9)	11.8 (8.0)	57.1
Med - Med	362	5.3 (9.4)	1.8 (6.6)	14.7 (7.0)	87.7
Total/Av.	1047	6.6 (11.9)	1.8 (5.4)	18.9 (11.7)	70.2

Cropping Seasons, Acreage of Main Food/Cash Crops

Potential	Cropping Season (%)		Acreage of Crops (sd)					
	One	Two	n	Coffee	Tea	Napier	Maize	Beans
High – Low	22.5	74.5	195	0.0 (0)	0.2 (0.7)	0.2 (0.6)	0.9 (1.6)	0.3 (0.5)
High – Med	0	100	173	0.6 (0.9)	0.2 (0.6)	0.4 (0.6)	0.6 (1.0)	0.2 (0.6)
Med – High	12.9	87.1	290	0.3 (0.7)	0.0 (0.1)	0.2 (0.6)	0.8 (1.3)	0.7 (1.2)
Med - Low	22.5	77.5	182	0.5 (1.3)	0.0 (0)	0.2 (0.9)	1.0 (1.2)	0.8 (0.9)
Med – Med	45.5	54.6	138	0.0 (0)	0.0 (0)	0.1 (0.4)	1.4 (2.6)	1.1 (2.5)
Average			1015	0.3 (0.8)	0.1 (0.4)	0.3 (1.5)	0.9 (1.6)	0.6 (1.3)

Cattle Inventory and Mean Numbers/(sd)

Potential	Local		Crosses		Grade	
	n	Mean (sd)	n	Mean (sd)	n	Mean (sd)
High - Low	1	3.0 (3.0)	42	4.5 (3.4)	53	6.1 (5.4)
High - Med	9	1.7 (1.0)	92	2.1 (1.3)	191	2.1 (1.3)
Med - High	72	3.4 (2.8)	12	2.8 (2.0)	20	6.4 (14.6)
Med - Low	27	18.4 (13.5)	9	9.6 (4.4)	0	0
Med - Med	20	6.7 (9.2)	104	4.7 (5.6)	103	4.1 (4.8)
Average	129	6.9 (9.6)	259	3.8 (4.3)	367	3.5 (5.0)

Main Feeding System Practised (%) by Land use Zone - Now/Ago

Potential	Grazing	Semi Zero	Stall Feeding
High - Low	23/26	71/69	6/4
High - Med	7/21	24/18	69/61
Med - High	37/51	32/35	31/14
Med - Low	97/100	3/-	-/-
Med - Med	32/52	49/30	19/17
Overall	25/39	38/30	37/31

Predominant Dairy Breeds in the Herds (%)

Potential	Friesian	Ayrshire	Jersey	Guernsey	Bos Indicus
High - Low	68	27	2	1	2
High - Med	42	18	4	25	11
Med - High	17	6	1	2	74
Med - Low	-	-	-	-	100
Med - Med	46	23	3	9	19
Overall	42	18	3	12	25

Production Performance

Potential	Calving Interval (days)	Lactation Length (days)	Milk Prod. (litres)	Age at First Calving (mths.)
High - Low	519 (122)	669 (282)	5.1 (2.9)	31 (4)
High - Med	594 (259)	259 (364)	4.7 (2.3)	32 (6)
Med - High	621 (250)	541 (326)	3.0 (3.4)	38 (8)
Med - Low	519 (128)	593 (309)	0.9 (0.6)	40 (10)
Med - Med	522 (216)	447 (190)	4.8 (2.7)	33 (7)
Overall	560 (223)	560 (315)	4.4 (2.8)	33 (7)

Breeding and Source of Service (%)

Potential	Pregnancy rate	Source of service				
		Natural				AI
		Bull	GOK	Coop.	Private	Others
High - Low	52	78	2	10	10	0
High - Med	43	57	8	17	17	1
Med - High	41	58	8	3	26	5
Med - Low	52	100	0	0	0	0
Med - Med	53	70	9	3	18	0
Overall	48	73	5	7	14	

Quantities of Milk Consumed by Household, Amounts Sold and Price per Litre

Potential	Amt. Consumed (litres)	Amt. Sold (litres)	Price per litre (KSh)
High – Low	2.7 (1.6)	9.0 (6.3)	13.5 (2.4)
High – Med	2.0 (0.9)	4.6 93.9)	12.5 92.0)
Med – High	1.6 (0.7)	5.0 (5.7)	23.6 (7.4)
Med – Low	2.4 (1.1)	4.0 (2.4)	13.6 (1.8)
Med – Med	2.2 (1.0)	7.0 98.0)	12.5 (2.2)
Overall	2.2 (1.1)	6.3 (6.5)	13.7 (4.3)

Primary Milk Sales Outlets (%)

Potential	Individuals	Hotels/Shops	Traders	Coop/SHG.	Processors	KCC
High - Low	9	11	20	10	20	8
High - Med	42	11	28	17	0	1
Med - High	63	15	0	26	0	0
Med - Low	75	25	0	0	0	0
Med - Med	49	8	24	18	6	11
Overall	48	14	14	14	5	4

Main Diseases Reported (%)

Potential	ECF	Anaplasmosis	Mastitis	Worms	Respiratory
High - Low	33	39	2	4	10
High - Med	35	16	13	8	7
Med - High	51	6	3	8	12
Med - Low	74	12	0	3	0
Med - Med	56	12	7	7	6
Overall	50	17	5	6	7

Household Incomes for Dairy Household

Potential	<2,500	2,500-5,000	5,001-10,000	10,001-20,000	20,001-30,000	>30,000
High - Low	17	21	31	21	4	6
High - Med	11	42	30	11	3	4
Med - High	24	35	17	12	6	6
Med - Low	3	18	38	23	9	9
Med - Med	30	33	22	11	3	2
Overall	17	30	28	16	5	5

Household Incomes for Non-Agricultural Household

Potential	<2,500	2,500-5,000	5,001-10,000	10,001-20,000	20,001-30,000	>30,000
High - Low	0	0	0	0	0	0
High - Med	0	0	0	100	0	0
Med - High	12	19	26	23	8	12
Med - Low	23	23	46	6	3	0
Med - Med	54	25	8	4	4	4
Overall	18	13	16	27	3	3

Household Incomes for Non-Dairy Household

Potential	<2,500	2,500-5,000	5,001-10,000	10,001-20,000	20,001-30,000	>30,000
High - Low	54	0	31	15	0	0
High - Med	37	44	10	2	0	0
Med - High	27	44	27	3	0	0
Med - Low	14	43	29	0	0	14
Med - Med	53	30	5	1	1	1
Overall	37	32	20	4	0	3

Appendix 4 List of Supervisors

International Livestock Res. Institute (ILRI)	
William Thorpe	- Field Manager
Steven J. Staal	- Agricultural Economist
Amos Omore	- Research Officer
Matthew Kenyanjui	- Research Assistant
David Njubi	- Data Analyst
Liston Njoroge	- Research Assistant
Isabelle Baltenweck	- Graduate Fellow
Kenya Agric. Res. Institute (KARI - Muguga)	
Mark O. Owango	- Asst. Project Manager
Kinyua Muriuki	- Technical Officer
Francis Musembi	- Research Officer
Bernard Lukuyu	- T.O/Graduate Fellow
Omolo Bwana	- Technical Officer/Farm Manager
Ministry of Agriculture	
H. G. Muriuki	- Project Manager
G. Gichungu	- Livestock Prod. Officer
J. Mugambi	- PDLP Nairobi
J. Mutunga	- DLPO Nakuru
J. Mbaranya	- DLPO Nyandarua
M. Wachira	- DLPO Machakos
W. Mungai	- DLPO Murang'a
J. Lenemeria	- former DLPO Narok
D. Mwangi	- DLPO Kirinyaga
Gacheche M.	- Nairobi
Josephine W. Kirui	- Nakuru
D. K. Kigera	- Narok
G. O. Angugo	- Nyandarua
P. Munyua	- Kirinyaga
J. Ngugi	- Maragua
Ngie M./Njihia P.	- Machakos
S. Waithaka	- Murang'a

Appendix 5 List of Enumerators

Name	Sub-location(s)	District
S. M. Mwazi	Ngata/Njoro	Nakuru
W. Kirii	Ndundori	Nakuru
Lucy Nyota	Keringeti	Nakuru
N. Njoroge	Njoro	Nakuru
S. K. Kinyua	Ndoswa/Marioshoni	Nakuru
J. N. Karumba	Kambiriria/Turi	Nakuru
H. Khakula	Shawa	Nakuru
S. Tanui	Ol-Rongai/Kampi Moto	Nakuru
S.Kimani	Gichobo	Nakuru
Julius N. Kuria	Siapei/Likia Teret	Nakuru
G. G. Kemoli	Lenginet/Banita	Nakuru
F. K. Njunge	Munanda/Kirima	Nakuru
M. Mburu	Kabatini/Wendo	Nakuru
S. K. Kinyanjui	Township/Olopito	Narok
M. N. Kabui	Sakutiek/Enaibor Ajijik	Narok
J.Torome	Ntulele	Narok
J. C. Njoroge	Kanjuiri/Mawingo	Nyandarua
G. M. Githaiga	Gathara/ Karati	Nyandarua
P. K. Muturi	Gitwe/Bamboo	Nyandarua
J. G. Gichuki	Kahuru Muruaki	Nyandarua
I. N. Mwangi	Rurii	Nyandarua
S. Gicheru	Ruiru	Nyandarua
Lucy M. Njoka	Thirikwa/Nyangeni	Kirinyaga
M. Macharia	Mukui/Nguguini	Kirinyaga
J. M. Maina	Kagumo/Kariru	Kirinyaga
Nancy Kibugi	Gitaku/Kianjege	Kirinyaga
J. Wainaina	Mirichi/Ngiriambu	Kirinyaga
A. Muthoka	Kithangaini/Ithini	Machakos
J. N. Kibunja	Vyulya/Mithini/Kamwala	Machakos
J. K. Mbuvi	Kiboko	Machakos
J. Mulembu	Isinga/Iia-Itune	Machakos
J. Nyamasyo	Sengani/Kambusu	Machakos
K.Mwaura	Kariua	Maragua
B. K. Mungai	Githunguri/Githuya/Kariti	Maragua
S. K. Kagiri	Kimathi/Nyakihai	Murang'a
S. J. K. Thige	Kahuti/Gatheru	Murang'a
F. N. Kuguru	Kiria/Kahuro	Murang'a
J. N. Kiragu	Ichichi/Nyakahura	Murang'a
S. O. Ayuko	Kairo/Gacharageini	Murang'a
J. D. Kamau	Gikui/Gacharaigu	Murang'a
P. Imodoi	Roysambu	Nairobi
Agnes Rutunu	Kasarani	Nairobi
Rebecca Ariko	Kibera/Golf Course	Nairobi
E. Nyongesa	Mugumoini	Nairobi
Mary Ambatsa	N. West/Mugumoini	Nairobi
Vitalis. Ounga	Kahawa North	Nairobi