KARI/MoA /ILRI Collaborative Research Project Report

Characterisation of Dairy Systems Supplying the Nairobi Milk Market

A Pilot Survey in Kiambu District for the Identification of Target Groups of Producers

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EXECUTIVE SUMMARY

Background to the study and approach
This report presents the results of a characterisation study of dairy systems carried out collaboratively in 1996 by ILRI, KARI and MoA, in Kiambu District of Central Province. The impetus for the study came from a recognition that important changes have taken place in the Kenyan dairy sub-sector since liberalisation of livestock markets began in 1989, and as a result of increasing population pressure on land resources. This study is the pilot phase of a larger collaborative study to characterise dairy systems across the milk sheds supplying the Nairobi urban area, and as such was used to develop the necessary analytical methodologies. These methodologies are based on a conceptual framework for dairy system analysis developed by ILRI (Rey *et al.* 1993).

The overall objective of the study was to carry out a characterisation of the dairy system in the selected site in such a way as to allow better targeting of future dairy research. Thus the characterisation focused on identifying constraints and opportunities within smallholder dairy systems whose alleviation or exploitation, respectively, could be enabled by targeted research. The characterisation also identified the groups of farmers who are most in need of research and development intervention. As mentioned, an additional objective was to develop dairy characterisation methods for use in ongoing collaborative studies in Kenya and in other parts of SSA, Asia and Latin America.

To collect the necessary data, a survey was conducted on a stratified random sample of 365 households from Kiambu district. The sample was stratified by land-use zones, which were defined by main cash crop: coffee, tea and horticulture or food crops. The survey instrument was a pre-tested structured questionnaire that was developed with assistance from field extension staff. Tabular analysis of the data gathered yielded information on farm/household resources and characteristics, cropping and feeding practices, reliance of input and output markets, herd structures, animal disease control practices and prevalence, and changes in farm practices over the previous 10 years. Further cluster analysis identified groups of farm/households which may deserve specific research attention.

Study findings
Since the sample incorporated non-agricultural households randomly with agricultural farm/households, inferences can be made as to the importance of dairying in the district. Of the 365 households, 93% were agricultural, and of those 77% kept dairy cattle. The households averaged 6.2 members, and 28% of them were female-headed. Over half of the households reported monthly cash income of less than Ksh 5,000, although this was fewer among households with dairy animals. Of dairying households, over 40% reported dairying to be their main source of income. The survey showed that dairying is clearly an important income-generating activity for a majority of households in Kiambu, and probably the single most important farming activity in the district.

The agricultural households held on average 2.7 acres each, the tenure of most of which was freehold. Less than a third of farms reported ownership by traditional land

tenure. Of the farms surveyed, 15% grew tea, 24% grew coffee, and the remainder grew only food crops, mainly maize, beans and Irish potatoes. Vegetables were grown by many for sale as well as consumption. The largest change reported by farmers during the last 10 years was the adoption of the cultivation of Napier grass: 14% of households reported taking up this technology during that period, reflecting the growing intensification of dairying practices in the area. An average of 0.4 acres of Napier was reported grown by farmers, which was about the same as the area devoted by them to maize, further underlining its importance. Based on these figures, Napier was estimated to occupy some 15% of all the arable land in Kiambu.

Similarly in the coffee zone 52% of households without dairy cattle hired labour compared to 89% among those with dairy. In both zones more dairy households had permanent labour, and in the horticulture zone more hired casual labour. These results suggest that the role of dairying in generating employment within producer communities may be quite important, and thus the positive income effects of dairying can be found not just within producer households, but secondarily among the households supplying them with labour. Unmeasured in this survey is the effect of both of these forms of dairy-derived income on creating demand for locally-produced goods

Respondents reported that most farm decisions were made either jointly by husband and wife or by the wife/female head. Also, most farmers reported that dairy co-operative membership was in the name of the wife or female household head, and that generally women controlled the income from milk sales. The role of men on farm seems particularly oriented to cash crops and to decisions regarding animal sales and purchases.

Dairy farmers kept an average of 3 cattle, mostly grade dairy or crosses of Holstein-Friesian breed. Cows formed half the herd overall, and combined with heifers, over 70% of the herd. Herds are thus focused on milk production, with few replacement animals kept. Analysis of herd replacement suggested that overall the herd might be in decline, with a net loss of 8% of animals, comprised of 6% of females and 23% of males. Mortality rates among cows overall was 11%. These results may be related to competition for land use, and if borne out over time, suggest a decline in the herd in this high intensity area. Further research is on-going to explore these trends in more detail.

Most farm exclusively stall fed their cattle, especially where farm sizes were small. Farmers reported that this practice had increased significantly in the past 10 years, highlighting the growing intensification. Some farmers, however, continue to graze their animals. Seasonal feed shortages are experienced by most farmers, at which time farmers purchase fodder or concentrates. The results show purchased fodder and feed to be crucial components of smallholder animal nutrition, with half of zero-grazing farms reporting purchases as their main source of feed.

Through purchases, nutrients now appear to be imported in large quantities into the system. Overall, Artificial insemination was available and was used by about half of dairy farmers, primarily from the Dairy co-operatives. AI use appears to be in decline. East Coast fever (ECF), anaplasmosis, mastitis and intestinal worms were the major animal health problems farmers reported. A majority of farmers vaccinated their cattle against FMD, and three quarters used acaricides.

Animal performance was relatively poor, even in this region considered one of the best dairy production areas in Kenya. Average daily milk yield, annually adjusted, was 7.2 litres, with an average calving interval of 591 days. These results point to continued under-nutrition of dairy cattle in the area.

Partially as a result, a quarter of dairy household sold no milk. Of those who did, most sold mainly to co-operatives, although informal market sales were also important. Prices available on the informal market were approximately 1 Kshs. per litre higher.

Cluster analysis was carried out to identify patterns among dairy households in terms of level of intensification, household resources and access to services and markets. The analysis distinguished 4 main groups of dairy farms:

1) the informal resource-poor, who sold to the informal market and had little access to formal livestock services, and were often female-headed,
2) the co-operative resource-poor, who were co-operative members but still among the most poor,
3) the elite, who had larger farms, often were employed off-farm and were co-operative members, and
4) the specialists, who were distinguished from the others only by the large amount of fodder and feed that they purchased.

This analysis has allowed the more precise targeting of further detailed research into the feeding strategies, land-use trade-offs, and market behaviour of the two most resource-poor groups. This research is currently being conducted by MoA/KARI/ILRI.

Conclusions

The results clearly show the importance of smallholder dairying for income generation and employment across the entire Kiambu community, with a large proportion of households participating and relying on dairy as a primary income source. The results also indicate, however, that the process of intensification has occurred at a rapid rate over even the last 10 years, with consequent changes in livestock management, feeding strategies, and land allocation. Purchased feeds are now a primary nutrient source for smallholder producers, increasing their exposure to the market. Animals continue to be significantly under-nourished, however, leading to performance well below potential. Potentially related to this intensification process is the apparent decline in the herd, with even the number of females falling significantly.

Although some of these processes can be understood, the underlying strategies of smallholders for coping with land pressures and market forces are not well known. As other parts of highland Kenya follow the same trends, the success of smallholder dairying will depend on the ability of producers to adapt to these changes. The cluster analysis identified specific homogeneous groups of producers who share similar resources and strategies. Some are particularly resource-poor with limited access to services and formal markets, and may be especially vulnerable to the changing conditions. Through the on-going focused on-farm research targeted at these vulnerable groups, MoA/KARI/ILRI collaborative research is now closely examining the reasons for the strategies they choose, and identifying new production and market strategies which can alleviate their primary constraints.

1. INTRODUCTION

1.1 Since the surveys carried out in 1977 to develop the farming systems descriptions reported in the Farm Management Handbook (Jaetzold and Schmidt, 1983), there has been no systematic characterisation of Kenya's smallholder agriculture sector and its dairy sub-sector. In the 20 year interval many factors have influenced the production and marketing of milk by smallholders. These factors, which have been particularly important in the highlands, include:

- the growth of the rural population and the resultant pressure on land and fodder production (for example, the population of Kiambu District doubled between 1969 and 1989; C.B.S 1994);
- the growth of the urban population and its demand for milk and dairy products (between 1969 and 1989 the population of Nairobi increased 2.6 times, from 510,00 to 1,325,000; C.B.S 1994);
- the liberalisation of milk marketing in 1992; and,
- the privatisation of many input markets such as veterinary and artificial insemination services (Owango *et al*., 1998).

As these changes have occurred, farmers have apparently responded by intensifying their production system, such as through increased planting of forages. These farmer responses and their aggregate effect, however, have not been well documented. Further, little is known about individual farm/household response to these resource and market changes. Understanding the responses to these pressures on dairy production and marketing is an important step towards providing a supportive operational environment for the smallholder sector that is estimated to produce 80% of Kenya's marketed milk supply (DANIDA/MALDM, 1991). The first step towards this understanding is a rigorous and comprehensive characterisation of the dairy farm/households, based on their dairy activities, their resources, and their market interaction. This understanding is also critical if research is to effectively address the constraints and opportunities faced by these smallholder farmers.

1.2 Nairobi is by far the largest urban market for milk and dairy products in Kenya. Kenya Co-operative Creameries (KCC), the national dairy processor, markets approximately 65% of its milk and dairy products in Nairobi. Improving the operational environment for smallholders supplying the Nairobi milk market will depend upon a more conducive policy environment, improved services, as well as technology options for smallholder producers and market agents. The first step required in support of this development process is a systematic characterisation of the smallholder dairy sector to identify the target groups of producers supplying milk to Nairobi and their market agents.

1.3 Rey *et al.* (1993) presented a conceptual framework for the analysis of dairy systems using a production-to-consumption approach. Within that framework for dairy systems research, Rey *et al.* (1998) have described methodologies for the characterisation of dairy production and market linkages to consumption centres. Their methodologies were used as the basis for this pilot study.
The objectives of the study were to:

- characterise the dairy production of the smallholder sector in Kiambu District and

its market linkages;
- identify homogeneous groups of smallholder dairy producers based on household and farm resource endowments, production system and market participation;
- identify constraints to and opportunities for improving smallholder dairy productivity (particularly for resource-poor households) through interventions along the production-to-consumption chain; and,
- through this pilot study, test and refine the methodologies for the characterisation of dairy production systems, target group identification, and constraint and opportunity analysis, in preparation for studies covering the milk shed serving the Nairobi market.

2. SELECTION OF SURVEY SITE

2.1 Kiambu District was selected for the pilot survey for the following reasons:

a) Central Province, which borders the Nairobi metropolitan area, is a major supplier of milk to the Nairobi market;

b) Kiambu District has a long history of smallholder dairy production and marketing;

c) it has a wide range of agro-ecological zones and land-use systems, many of which are changing in response to market opportunities;

d) dairy co-operative societies are the principal outlets for milk formally-marketed by smallholders; in 1995 Central Province had 66% of the national active membership of dairy co-operative societies, and 71% of their annual milk turnover (Karlen, 1995);

e) it is one of the three districts within the mandate area of KARI's National Agricultural Research Centre (NARC), Muguga, a lead institution in this pilot study, and;

f) the two collaborating research institutions, KARI and ILRI, and the MoA's extension staff in Kiambu had the effective working relationship required to plan and carry out the survey and to interpret its results.

3. SURVEY DESIGN AND IMPLEMENTATION

3.1 Based upon the survey instrument presented by Rey *et al.* (1998) and the associated lists of performance indicators and functional parameters and practises, a structured questionnaire was developed in collaboration with NARC-Muguga, KARI's National Veterinary Research Centre (NVRC) and the Kiambu extension staff. The questionnaire was field-tested by teams of research and extension staff, including those who were to supervise the enumerators carrying out the survey.

3.2 The questionnaire was divided into sections covering: household composition and labour availability; farm activities and facilities; livestock inventory; dairying history and production practises; dairy marketing; livestock management and health services; co-operative membership; and, household income and sources. The questionnaire with coding sheets are presented as Appendix I.

3.3 Based on the agro-ecological zones described by Jaetzold and Schmidt (1983) and field knowledge, three major land-use systems, tea/dairy (agro-ecological zones UH1 and LH1), coffee/dairy (UM1 and UM2), and horticulture/dairy (UH2, UM3, LH2, LH3 and LH4-5) were identified in Kiambu District. In each of these land-use systems eight sample sublocations (a total of 24 out of the 99 sublocations) were selected randomly as the geographical sample for the survey (Figure 1).

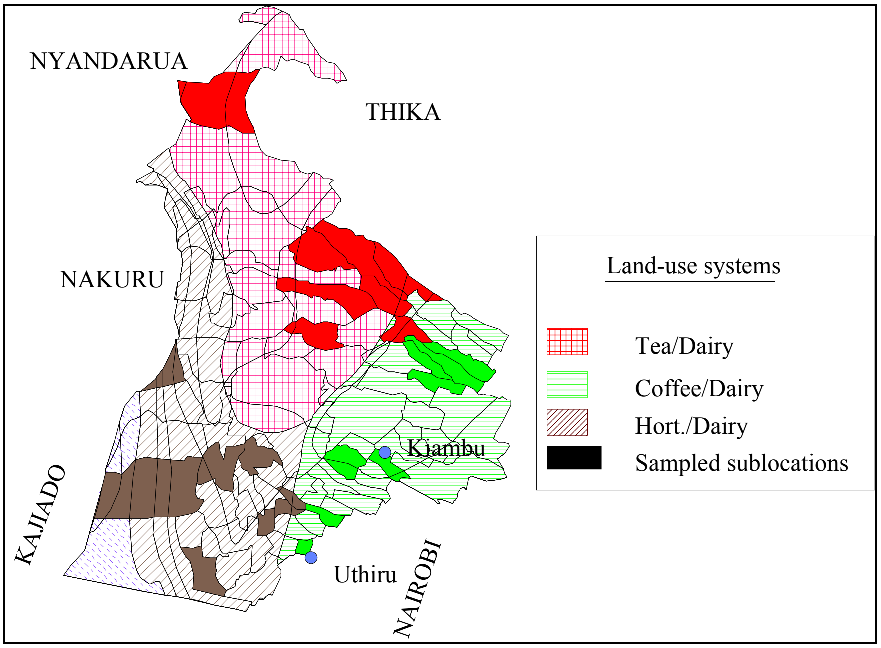

Fig. 1 Map showing Sublocations sampled in the major land-use systems in Kiambu District

3.4 The number of households to be surveyed in each sublocation was taken as a proportion of the number of households in the sub-location (Table 1) obtained from 1989 census figures (C.B.S, 1994). The sample size was obtained from estimating the number of observations potentially needed to distinguish between the three land-use systems a difference of 20% in some of the important farm/household variables.
Assuming a desired confidence interval of 95%, and using a coefficient of variation of 68%, which was the observed cv in Kiambu dairy herd size from previous studies (Kaguongo, 1996), a minimum sample size of 89 in each land-use zone was calculated.[1]
In order to capture as much local variation as possible, the sample in each zone was spread across 8 sub-locations selected randomly.

Table 1. Number of households reported in the 1989 C.B.S census for the sublocations covered by the survey and the number of households in the

[1] Calculation of sample size in each stratification class, 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).

survey by land-use system and sublocation

Land-use zone	Sublocations	Households		
		1989 Census	No. sampled	
Tea/Dairy	GATHANGARI	1127	13	
	KANJAI	1207	14	
	GATHUGU	1181	14	
	KAMAE	785	10	
	KAMBURU	1249	14	
	KAMUCHEGE	874	10	
	NYANDUMA	1403	16	
	GACHOIRE	999	12	(Total - 103)
Coffee/Dairy	KIBICHIKU	1746	21	
	UTHIRU	3388	31	
	KARURI	1182	13	
	GATHANGA	1214	15	
	RIUKI	1268	14	
	GIATHIEKO	795	10	
	KIMATHI	1287	14	
	NYAGA	1633	19	(Total - 137)
Horticulture/Dairy	LUSIGETI	1145	13	
	GITARU	1825	22	
	KERWA	2082	24	
	CHURA	299	10	
	RUKU	891	10	
	THIGIO	1608	19	
	NDIONI	372	10	
	NGECHA	1508	17	(Total - 125)
Total	24	31,068	365	(1.2%)

The chosen sample size then required approximately 11 observations in each sub-location. However, in order to maintain proportionality, the number of observations in each sub-locations was adjusted to reflect the proportion of the number of households, resulting in sample sizes of 6 to 31 in each sub-location. After maintaining a minimum of 10 observations in each sub-location, the total sample size obtained was 365 households (or 1.2 percent of the estimated households in the sample sublocations).

3.5 Survey maps for each of the 24 sublocations 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-location, and with the help of sub-location Chiefs, marked on the sub-location map the main landmarks (a landmark was defined as any permanent feature like a trading centre, a school, a church, or a factory). Two 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 5th 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.

3.6 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. The interviews were carried out between 24th June and 8th

July 1996 by enumerators who were selected from among the front-line and supervisory extension staff of the MoA in Kiambu District. During the first week of the survey, each completed questionnaire was checked with the enumerator by senior extension and research staff within one day of the interview. Any errors were discussed with the enumerator in an attempt to improve the accuracy of the subsequent interviews, and to ensure that, where necessary, the enumerator returned to the household to correct the errors. Appendix II lists the staff from the MoA, KARI and ILRI who designed, supervised, enumerated and analysed the survey.

3.7 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 EpiInfo, DBase and SAS software.

3.8 The results of the survey are presented first as tabular descriptive analyses. The data is then used in principal component and cluster analyses to identify homogenous client groups of dairy producers. These clusters represent recommendation domains which will form the focal points for developing policy and technical interventions, by targeting them at identified groups of resource-poor farmers with particular characteristics. These interventions will be developed through participatory processes for identifying and testing priority policy options and technical improvements. More in-depth research will be carried out, focused on the target groups, to explain the observed patterns in dairying related to household characteristics. This will lead to better understanding of the processes limiting smallholder dairy productivity and to the better targeting of solutions to alleviate those limiting factors.

4. RESULTS FROM DESCRIPTIVE ANALYSES

4.1 Proportion of Agricultural and Dairy (cattle) keeping Households

Since the sample selection was completely random, the households surveyed included a wide spectrum of household types. Of the 365 sample households, 340 (93%) were agricultural (they had and used land for farming), while the remainder (7%) were residential (non-agricultural).[2]

[2] Non-agricultural households were most frequent in the peri-urban Uthiru sub-location in the Coffee/dairy zone (Figure 1).

Of the agricultural households, 77% (261) kept cattle. The proportion of agricultural households with cattle was the highest in the Tea/dairy zone (86%) and lowest in the Horticulture/dairy zone (69%) (Table 4.1).

Table 4.1 Number and % of total households surveyed, total agricultural, and agricultural households with cattle, in the tea, coffee and horticulture land-use zones.

Land-use zone	Total House-holds surveyed	With land (agricultural)		With cattle	
		n	% in zone	n	% in zone
Tea	103	102	99	88	86
Coffee	137	118	86	90	76
Horticulture	125	120	96	83	69
Total	365	340	93	261	77

Figure 4.1 shows the division of the sample households overall into agricultural, dairy, co-operative members and active co-operative members. Active members are those registered members who are currently delivering milk. Reasons for non-delivery of milk include temporarily dry cows, death of cows, or cessation of dairying. As seen in the figure, 41% of the dairy households were not co-operative members, highlighting the importance of milk sales to other outlets, particularly the informal market. Of co-operative households, 32% were not active, and were either selling their milk elsewhere or who had no milking cows at the time of the survey.

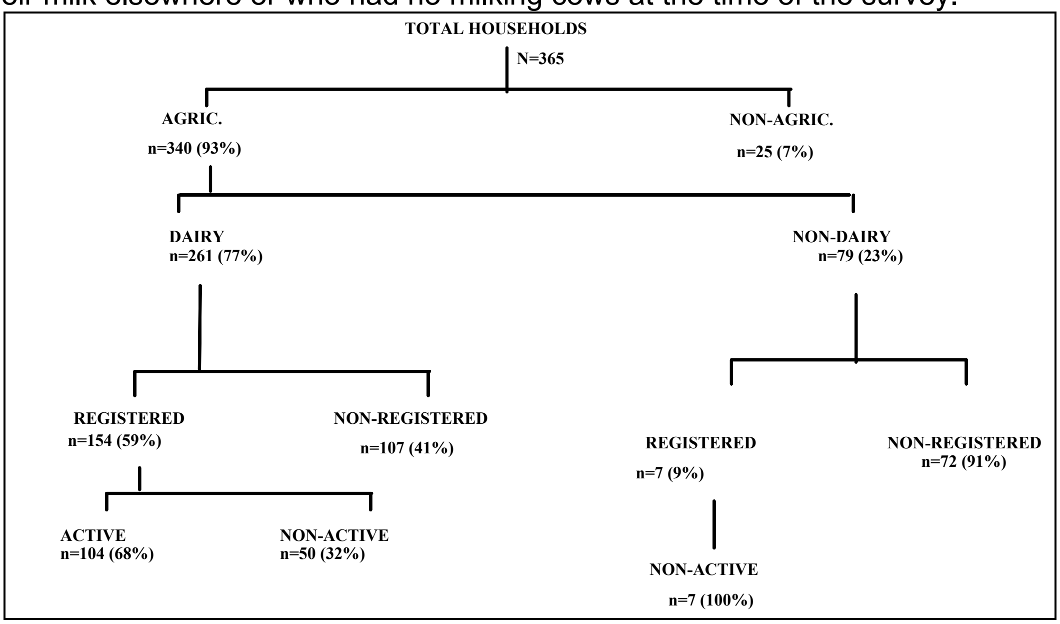

Fig. 4.1 The proportion of sample households that were: agricultural or non-agricultural; dairy or non-dairy; registered or not registered with a dairy co-operative society; and delivering (active member) or not delivering milk to the co-operative.

4.2 Household Composition and Gender Differentiation

On average households (n=365) had 6.2 members (SD = 3.24; range = 1-25) (Table 4.2) of whom 2.7 were adults. While the average household had 1.1 youths (15-22 years) and 2.2 children (0-14 years), half the households had no youths, and more than half had no children aged between 0 and 7 years, nor between 8 and 14 years. Neither mean household size nor composition was affected by the land-use zone nor by whether the household kept dairy cattle. The ratio of youths and children to adults was thus only 1.2, which may be regarded as relatively low.

Table 4.2 Household Size and Composition

Age group (yrs)	Mean no. per Household	S.D .	Range	% of House holds with > 0
0 - 7	1.1	.41	0 - 7	52
8 - 14	1.1	.23	0 - 5	57
15 - 22	1.1	.71	0 - 20	50
23 - 65	2.7	.87	0 - 10	93
> 65	0.2	.55	0 - 2	16
Total	6.2	.24	1 - 25	

The mean age of agricultural household heads was 49 years; 72% of those were males (Table 4.3). Over a quarter were therefore female, although fewer women were also the owners of the farms. In 90% of households the head was recognised as the farm manager; in most of the exceptions the husband was household head, but the wife managed the farm.
Farm management was the primary activity of over 90% of household heads of tea-growing farms, and of 50-70% of the household heads in the other zones and farm types. In the rest of the cases, the primary activity was either business or employment off-farm. Half of the male and of the female heads had received primary education, but twice as many male as female heads had secondary education and six times as many female heads had had no formal education (Table 4.3).

These results show a relatively high proportion (28%) of female-headed households, which in a few cases include households where husbands live elsewhere. It is not known whether this household structure is particularly characteristic of the Kiambu area, where some husbands may live and work in nearby Nairobi. As indicated, however, the women tended to be less educated, which may affect not only their ability to manage specialised dairy animals, but also their level of access to public services. These issues will be further discussed in the cluster analysis.

Table 4.3 Sex of household head, farm-ownership and education level.

	Male (%)	Female (%)
Sex	72	28
Average age (years)	49	49
Farm owner	81	19
Education Level		
No formal education	4	23
Primary	51	52
Secondary	32	14
Post secondary	2	3

Technical training	7	6
Adult literacy training	3	2
Other	<1	1

There was no marked gender differentiation in the reported primary responsibilities on farm. This was confirmed by a smaller follow-up survey to examine more closely the gender roles in decision-making. Ouma (1997) reported that in decision-making related to cash crops, food crops, fodder and dairying, more than half of farms declared that such decisions were made either jointly by husband and wife or by the wife/female head. Also, most farms reported that the dairy co-operative membership was in the name of the wife or female household head. Most farms also reported that women controlled the income from milk sales. The role of men on farm seems particularly oriented to cash crops and to decisions regarding animal sales and purchases (Ouma 1997). These results highlight the importance of dairying for improving the welfare of women in agricultural communities, through improved access to income and, through co-operatives, to services and potentially to community decision-making.

4.3 Labour Resources

Labour resources consist of the household or family labour available, plus casual or long-term hired labour. Of the agricultural households nearly 40% used family labour solely, while half employed casual labourers, and 15% hired labour on a permanent (long-term) basis. The dependence on family labour and the employment of permanent and casual labour varied with the presence of tea or coffee, and of dairy cattle. In the tea and coffee zones more households growing those cash crops depended on hired than on family labour, with approximately 60% of farms employing casual and 20-30% permanent labour. Casual labour was reported to be used particularly for all aspects of food cropping, and for the harvesting of cash crops, especially tea. There were apparently no tasks for which the permanent labour had primary responsibility.

In all zones, however, dairying was associated with an increased use of hired labour. In the horticulture zone only 28% of households without dairy cattle hired some form of labour, compared to 54% among those with dairy cattle. Similarly in the coffee zone 52% of households without dairy cattle hired labour compared to 89% among those with dairy. In both zones more dairy households had permanent labour, and in the horticulture zone more hired casual labour. These results suggest that the role of dairying in generating employment within producer communities may be quite important, and thus the positive income effects of dairying can be found not just within producer households, but secondarily among the households supplying them with labour. Unmeasured in this survey is the effect of both of these forms of dairy-derived income on creating demand for locally-produced goods, such as furniture, building materials, etc.

Family members working off-farm may reduce the labour resources available for farming and dairying activities. The overall number of active adults (15 - 65 years) working off-farm was 438, yielding an average number of adults working off-farm in each household (n=340) of 1.3 members, representing 34% of all adults in this category. The presence of dairy animals may reduce the proportion of adults working off-farm, as the dairy households reported 31% of adults working off-farm, compared to 43% in the non-dairy households. The proportion working off-farm was not apparently affected by land-use zone, but in each zone, dairying was similarly associated with lower levels of off-farm employment. This may simply reflect the importance of dairy production as an income-generating activity which can compete favourably with opportunities off-farm.

4.4 Household Income Categories

The total household cash income (from sales of farm production plus off-farm income) was reported in six broad classes. The frequencies of non-agricultural, agricultural but non-dairy and dairy households within these groups are shown in Figure 4.2. These income classes do not reflect the value of farm production that is consumed within the household, and thus under-represent the income of the farming households relative to others. They also suffer from unreliability, as households were often reluctant to reveal their income. They nevertheless serve as general indicators of level of household income.

The categories in Figure 4.2 are non-agricultural households (7% of the total), agricultural households without dairy animals (22%) and households with dairy (71%). The percentages shown represent percent within each category of agricultural/dairy household type.

The results show greater representation of dairy households as income goes up, with nearly all of the highest income households keeping dairy animals.

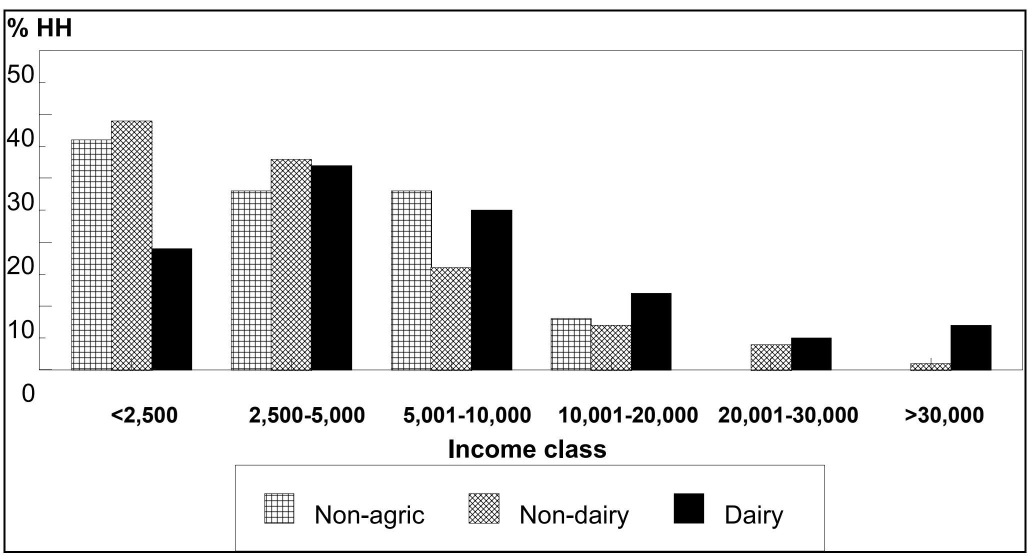

Fig. 4.2 Frequencies of households reported in relative cash-income classes.

Over half of the surveyed households reported monthly cash incomes of less than Ksh 5,000, with dairy households having a lower proportion of these low income households than other agricultural or the non-agricultural households. Consequently on average, agricultural households with dairy cattle had higher incomes than those without dairy cattle.

For over 40% of dairy households, the dairy enterprise represented the main source of income; cash crops and non-farm income were the main sources for 20 and 21% of dairy households, respectively, and food crops and poultry, 10 and 3%, respectively. Clearly in Kiambu District, dairying is a favoured agricultural enterprise; it is practised by three quarters of agricultural households for 40% of whom it is the main source of income.

When these results are combined with those for off-farm labour, in which it was reported that dairy farmers worked off-farm at lower rates than other farmers, it further supports the income and employment generating effect of dairying. The fact that dairy farmers can work less off-farm, and yet generate higher cash income levels, suggests that dairying is an important employment opportunity for agricultural households.

4.5 Land Tenure, Land Use and Land Size

4.5.1 Land Use and cropping practises

The survey was stratified by three land-use systems: tea, coffee and horticulture with dairy (Table 4.1), based on the classification of Jaetzold and Schmidt (1983). Horticulture in this case simply refers to the growing of food crops, mainly maize, beans, kales etc mainlly for subsistence usually but often also for sale.

The classification identifies areas agro-ecologically suitable for growing a specific crop. In practise only half the sample farms in the tea/dairy zone grew tea, and less than half in coffee/dairy zone grew coffee (Table 4.5). In the tea zone there were many farms with coffee, but, as expected, the reverse was not the case; nor was coffee grown on many farms in the horticulture zone. In the coffee zone, the actual growing of coffee was positively linked to increased keeping of dairy cattle.

Table 4.4 Presence of tea, coffee, horticultural crops and dairy on farms by land-use zone.

Land-Use Zone	With tea	With coffee	Horticulture only	Total
Tea/dairy Zone				
With dairy	47	29	12	88
Without dairy	3	3	7	13
Coffee Zone				
With dairy	1	38	51	90
Without dairy	0	6	21	27
Horticulture Zone				
With dairy	0	5	78	83
Without dairy	0	1	36	37
Overall				
With dairy	48	72	141	261
Without dairy	3	10	64	77

The main food crops grown were maize, beans, Irish potatoes, bananas and various vegetable crops of which the most frequent was kales. Maize was grown either in a sole stand or intercropped with beans, or with beans and potatoes, and less frequently with these and bananas. By contrast napier grass, the only fodder crop of importance, was grown as a sole stand in over 90% of cases. There was some interplanting of food crops, mainly beans, in coffee stands, but most frequently it was a sole stand.

Changes in cropping systems or their component crops were identified during the last 10 years, based on farmer recall. Some 14% of households reported adopting the cultivation of napier grass during the last ten years[3]. This introduction was reported mainly on farms with dairy cattle in the tea and coffee zones. This supports anecdotal evidence that napier cultivation has increased in recent years, reflecting the growing importance of dairying in this high-potential area. Dairy households were found to plant on average 0.5 acres (0.2 ha.) of Napier grass. Of interest is also the fact that non-dairy agricultural households reported planting an average of 0.13 acres (0.05 ha.) of Napier grass. This reflects the fact that Napier is grown by some farmers for sale to dairy farmers, and can currently obtain a price of some 5 Ksh per kg of dry matter[4], although the price is highly variable seasonally. Extrapolated to reflect the estimated number of households in Kiambu overall, the acreage figures suggest that some 15% of all arable land in Kiambu is planted with Napier grass. This compares to an estimate from the survey of 14% of arable land planted to maize, the staple food crop (but also an important fodder source), underlining the importance of Napier grass in the Kiambu farming system.

Fruit trees (citrus, pears, mangoes, avocados etc.) were reported by 11% as being grown now but not 10 years previously (Figure 4.3) Another significant change was that a quarter of the tea growers with dairy had first introduced their tea only during the last 10 years.

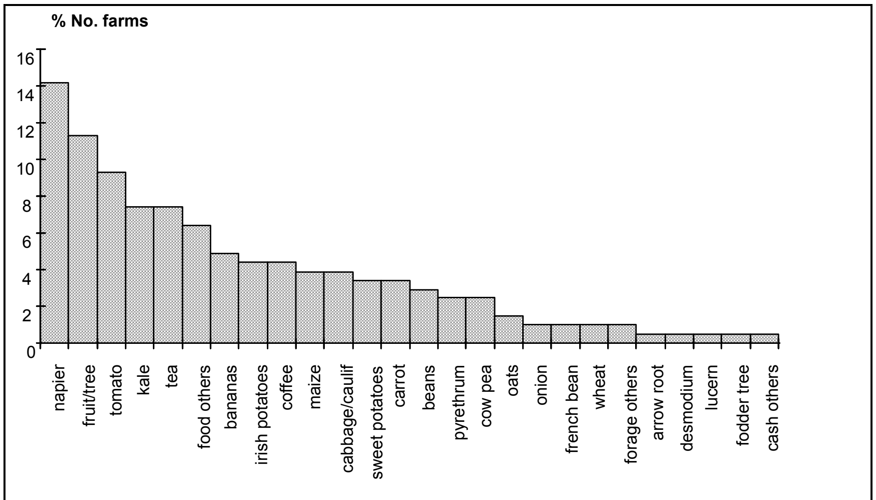

Fig. 4.3: Crops grown now and not 10 years previously

[3] Figures reported for changed cropping in last 10 years apply only to households established for at least 10 years.

[4] Freshly-cut Napier is approximately 20% dry matter.

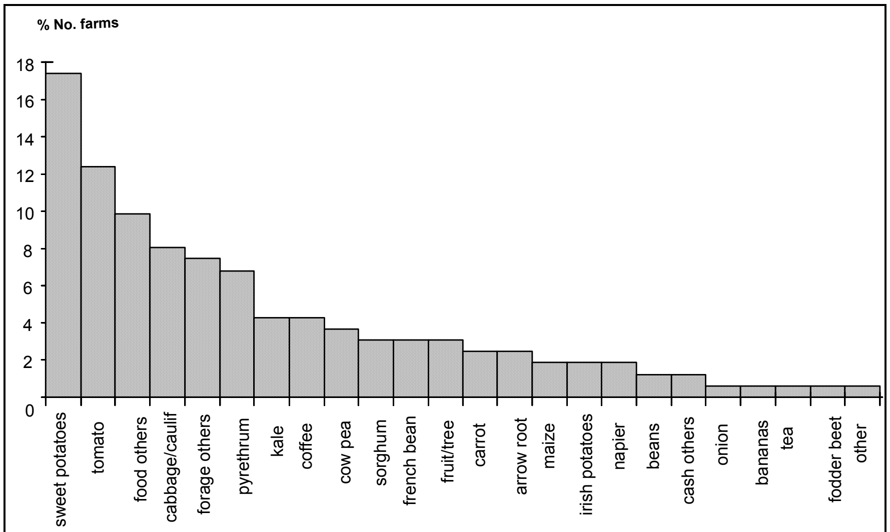

Fig. 4.4: Crops grown 10 years ago and no longer

Prominent amongst the crops no longer grown now compared to 10 years ago were sweet potatoes (Figure 4.4). In the horticulture zone about 20% of dairy, and a lower proportion of non-dairy, farms had stopped growing sweet potatoes. Some of these shifts away from relatively low-value vegetables may be related to the reported increases in the planting of napier, suggesting that resources may have been shifted from low value activities to higher-value dairying.

In each of the three land use zones the application of manure was practised by about 90% of farmers. In the coffee and horticulture zones more dairy than non-dairy farms applied manure, a result clearly related to the availability of manure. Some fertiliser was also applied by the majority, although as with manure, this was more frequent among dairy than non-dairy farms in the coffee and horticulture zones. This may be related to more regular cash flow or higher cash incomes, enabling the purchasing of fertiliser.

Very few farms reported using irrigation. The exceptions were in the horticulture zone and non-coffee growers in the coffee zone.

4.5.2 Land Tenure and Farm Size

The main land tenure system reported by most farms was freehold (68%); less than a third were reported as holding land under traditional ownership systems (Table 4.4). Few households rented plots or indicated the use of roadside land. The fact that roadsides are nevertheless widely observed to be planted with napier and food crops, suggests that respondents may not have revealed the full extent of their activities on public land.

Table 4.5 Average land holding size by type of tenure

Type of tenure	% of households	Avg. acreage	Range (acres)
Traditional	27	1.7	0.2-15.5

Freehold	68	3.2	0.1-20.0
Rental plots	2	1.2	0.5-1.5
Roadside plots	1	2.2	0-2.2

The Tea/dairy zone had the highest frequency of farms established within the last 15 years, 50%, compared to only 33% of farms in the Coffee/dairy zone. Correspondingly only 15% of farms in the Tea/dairy zone were established 30 or more years ago, compared with 27% of farms in the Horticulture/dairy zone.

The overall mean land holding was 2.7 ac (1.1 ha). In most of the households this land was held on one (55%) or two (25%) plots. One third of farms had 1 ac. (0.4 ha.) or less, and two thirds had 2.5 ac. (1.0 ha.) or less. Less than 20% of farms held over 4 ac. of land (1.6 ha.) (Figure 4.5).

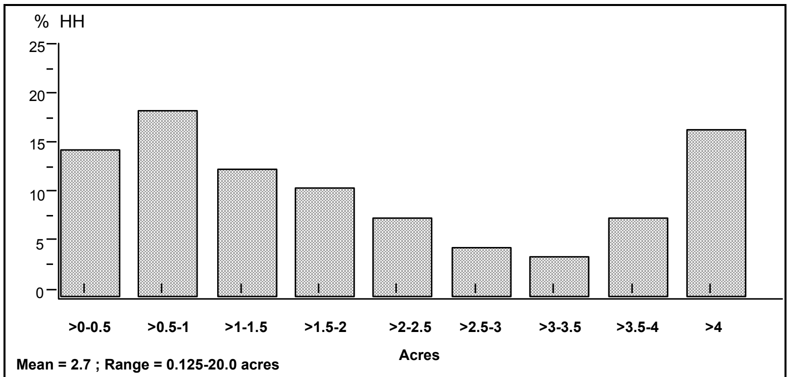

Fig.4.5: Farm sizes

Mean farm sizes varied considerably across land-use zones and among farms within zones (Table 4.6). The smallest farms were those in the coffee zone without coffee; compared to coffee growing farms with a mean size of 3.61 ac. (1.42 ha.), those without coffee but with dairy were approximately half the size, 1.72 ac. (0.49 ha.), while farms without either were half as small again, 0.75 ac. (0.30 ha.) Farms growing tea or coffee devoted, on average, a third of their land to these cash crops. Dairy farms, on average, planted between 15 and 23% of their land to forages (almost entirely napier grass) , and 26 to 44% to forage and maize combined (Table 4.6), areas consistent with the fodder requirements of stall-feeding of dairy cattle in the zones (Table 4.10). As in the coffee zone, farms in the horticulture zone without dairy cattle were as small as 2.32 ac. (0.91 ha.) than those with dairy (2.86 ac. - 1.13 ha.), and the non-dairy farms used more land for growing maize (31% compared to 21%).

4.6 Farm Infrastructure And Transport

The majority of farms in the survey sample had poor access to municipal infrastructure. Only 36% had piped water, 22% electricity and 5% a telephone. Only 9% of farms had both piped water and electricity. Less than half had a source of water on the farm. If water was carted from off-farm for the livestock, the distance was generally short with the exception of the horticulture zone where 40% of dairy farms hauled water from over 1 km. Nearly 40% of households had no farm or household transport means, such as a vehicle. The highest proportion with no transport were the non-coffee growing farms in the coffee zone and the non-dairy farms in the horticulture zone. These farm types had the least land.

The majority of households depended upon wheelbarrows and bicycles; 25 to 40%, according to the farm type, had only a wheelbarrow for transport. Approximately one household in twelve had motorised transport; only 1% of households used animal draught power.

Table 4.6 Mean area of land owned, the number of plots, the cropped area and areas under forages (mainly napier grass), maize, tea and coffee for farms in the tea, coffee and horticulture zones with or without the major cash crop and dairy.

Land-Use Zone	Tea Zone			Coffee Zone			Horticulture Zone		
	Tea+ Dairy	Coffee+ Dairy	Food crops+ Dairy	Coffee +Dairy	Food crops +Dairy	Food crops only	Food crops+ Dairy	Food crops only	Total
No. of farms	47	29	12	38	51	21	78	36	312
Total land, acres	3.74	2.94	2.81	3.61	1.72	0.75	2.82	2.32	2.68
No. of plots	1.89	1.55	1.91	2.02	1.90	1.43	1.79	1.69	1.80
Land cropped, acres	3.68	2.92	2.84	3.58	1.68	0.76	2.70	2.59	2.67
Forage planted, acres	0.79	0.65	0.36	0.57	0.26	0.05	0.55	0.22	
Maize planted, acres	0.47	0.27	0.41	0.40	0.31	0.14	0.60	0.73	
Forage planted, % of land	23	17	13	16	16	4	21	6	
Forage/maize planted, % of land	36	29	50	27	34	25	43	33	
Tea planted, % of land	34	-	-	-	-	-	-	-	
Coffee planted, % of land	-	36	-	36	-	-	-	-	

4.7 Livestock Inventory

4.7.1 Non-cattle livestock inventory

While cattle were the livestock species kept by the largest number of households, poultry, pigs, sheep and goats, rabbits or donkeys were kept by some households (Table 4.7). Most common were local poultry, kept by half of the agricultural households. Commercial (improved) poultry were less common, with layers reported by fewer than 5% of households (with most concentrated in the horticulture zone), and broilers by fewer than 1%. Small ruminants were also popular; 24% of households kept sheep, approximately three times as many as kept local goats (9%), while fewer than 6% of households had dairy goats (with none in the horticulture zone). Even fewer households kept pigs (3.5%), while as many households kept rabbits (9%) as kept local goats. Approximately one household in 20 kept one or more donkeys; the majority were in the horticulture zone. The number of sheep and local poultry kept by the non-cattle keeping compared to the cattle-keeping households was the same, while the number of dairy goats and commercial layers was higher for the latter group. The association between layers and dairy cattle is likely to result from the use by farmers of sifted poultry waste as an animal feed supplement. The numbers of rabbits and pigs were higher for non-cattle keepers. There were very few cases of households keeping livestock, including cattle, that they did not own.

Table 4.7: Proportion (%) of agricultural households with livestock other than cattle, the mean number, standard deviation and range.

Livestock	type	% Households	Mean	SD	Range
Poultry	Local	49.1	4.12	6.16	0-30
	Layers	4.7	9.10	55.85	0-800
	Broilers	0.6	0.60	10.85	0-200
Pigs		3.5	0.34	3.42	0-59
Sheep		23.5	1.07	2.73	0-26
Goats:	Local	8.8	0.33	1.33	0-14
	Dairy	5.6	0.16	1.02	0-15
Donkeys		5.0	0.06	0.30	0- 3
Rabbits		8.8	0.41	1.98	0-21

4.7.2. Cattle numbers and breeds.

Of the agricultural households, 261 (77%) kept cattle (section 4.1). The total herd was 784 cattle, an overall mean of 3.00 cattle per household (Table 4.8). Over 96% were dairy cattle; more than half were described as high dairy grades (having at least 75% exotic dairy genes), and the remainder as dairy crosses (having less than 75% exotic dairy genes). It is possible that the level of dairy genes reported by farmers was not always accurate, nevertheless the figures suggest that somewhat less than half of the grade animals were high dairy grade.

The animal performance analysis (section 4.11) indicates that genotypes are roughly accurate, as reflected in milk yields.

Table 4.8: Cattle Inventory and Mean Numbers per Household of Local, Dairy

Cross and High Dairy Grade types.

Breed	Total reported	Mean/hh	SD	Range
Local	30 (3.8%)	0.11	0.58	1- 6
Dairy Crosses	420 (53.6%)	1.61	1.83	1- 8
High Dairy Grade	334 (42.6%)	1.28	2.05	1-14
Total	784	3.00	1.91	1-14

The remainder of the recorded cattle population, fewer than 4%, were local (Small East African) zebu. The local zebu were kept by 13 households (5%), 8 with herds of only local zebu (having two thirds of all the zebu); the other 5 zebu-owning households also kept some dairy cattle. Consequently nearly 97% of cattle-keeping households had dairy cattle.

The dominant breeds in these dairy herds were Holstein-Friesian (51% of herds), Ayrshire (23%) and Guernsey (13%), with breed choice determined primarily by farmers seeking high daily milk yields. Farmers in approximately equal numbers cited increasing milk production for home consumption and for marketing as the reasons for having cattle with exotic dairy genes. Approximately a third of the farms had introduced exotic dairy genes 20 or more years ago, and about two thirds had had cattle with exotic dairy genes for at least 10 years.

4.7.3 Herd sizes and structures

As Figure 4.6 shows, the majority of herds were small. Two thirds of herds in the tea and horticulture zones had three or fewer cattle, while there were more herds of 4 or more animals in the coffee zone (Figure 4.6).

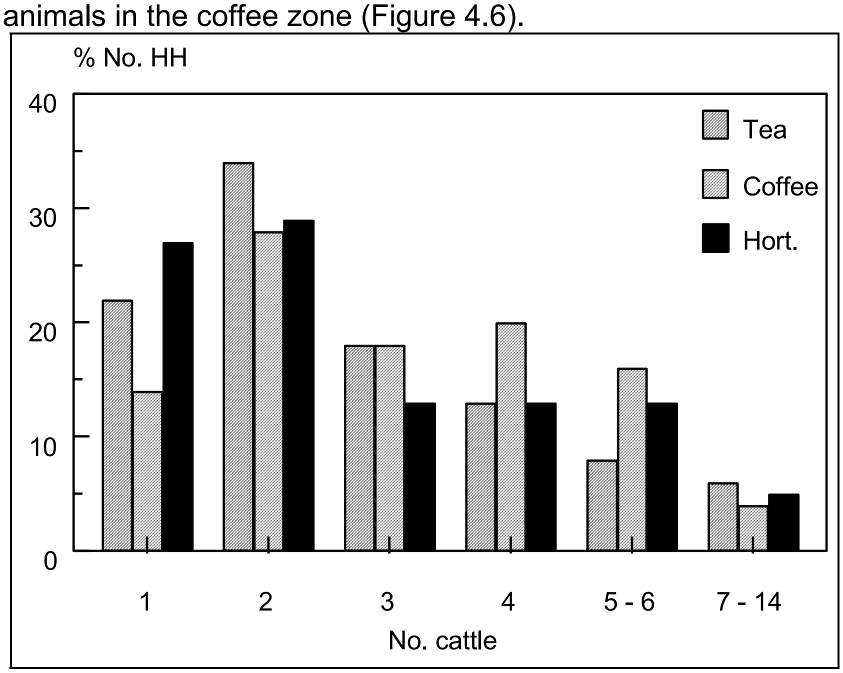

Fig. 4.6 Distribution (percent of households) of the size of cattle herds in the three land use zones.

The mean dairy herd size and composition in the three land use zones is shown in Table 4.9. On average, cows formed half the herd, 1.46 animals of the 2.98 overall mean herd size. They and the heifers formed over 70% of the herd. While the herds had, on average, approximately twice as many post-weaner females as males, there were similar numbers of pre-weaner female and male calves, suggesting that most males did not leave the herd until after weaning.

Table 4.9 Mean herd size and composition for farms with dairy cattle in the tea, coffee and horticulture land-use zones of Kiambu District.

	Tea		Coffee		Horticulture		Total	
No.	88		86		79		253	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Bulls	0.11	0.32	0.24	0.60	0.04	0.19	0.13	0.42
Castrated adult males	0.00	0.00	0.01	0.11	0.04	0.25	0.02	0.17
Immature males	0.41	0.67	0.23	0.48	0.44	0.732	0.36	0.64
Cows	1.30	0.85	1.70	0.96	1.38	0.92	1.46	0.92
Heifers	0.58	0.72	0.80	1.03	0.72	0.95	0.70	0.91
Pre-weaner calves:								
Females	0.20	0.46	0.17	0.49	0.14	0.52	0.17	0.49
Males	0.17	0.46	0.17	0.44	0.16	0.52	0.16	0.47
Total	2.77	1.74	3.36	2.04	2.84	1.90	2.98	1.91

The marginally larger herds in the coffee zone resulted mainly from having more cows and heifers (Table 4.9), while higher frequency (and hence mean number) of bulls in the coffee zone was offset by relatively fewer immature males.

Of the households with cattle, 88% had from 1 to 5 adult cows (among other animals), 49% had heifers, 14% heifer calves, 12% male calves, and only 11% had an adult bull (Figures 4.7 a and b). The majority of cattle-keeping households were therefore characterised by having only 1 (46%) or two cows (32%), with half of the households (51%) not having heifer replacements.

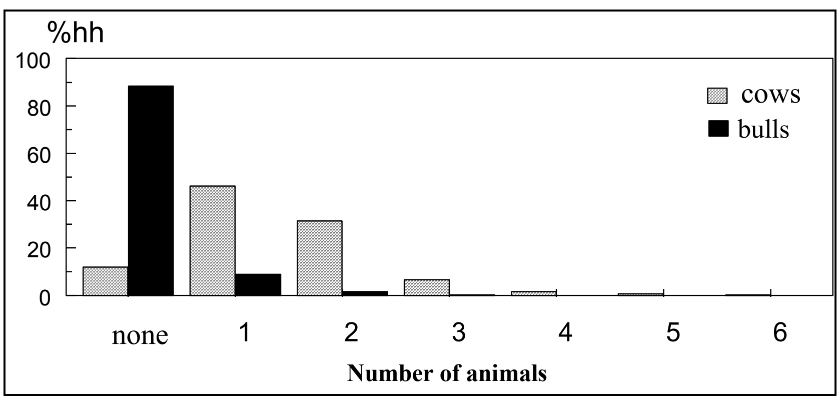

Fig. 4.7a Percent of cattle-keeping households with or without bulls and cows.

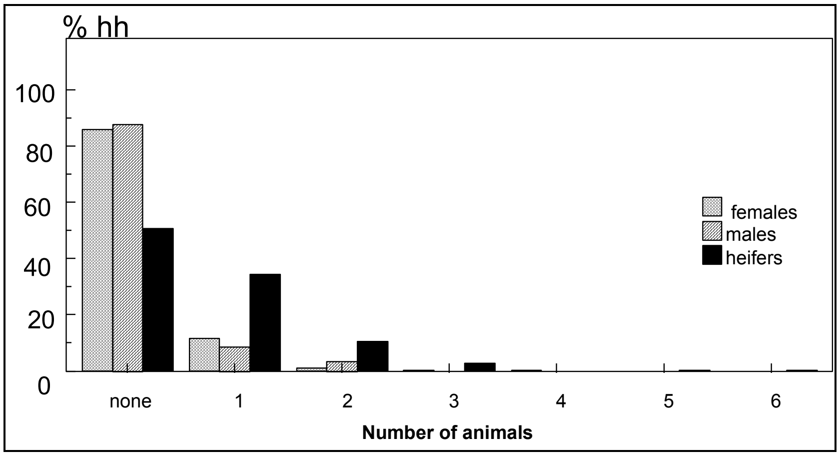

Fig. 4.7b Percent of cattle-keeping households with or without heifers or male or female calves.

Heifers (post-weaning females 3 years or younger) formed 15% of the post-weaning female population. The population of mature females (older than 3 years) was dominated by cows between 4 to 6 years of age (65%); there were few cows (9%) over 9 years of age (Figure 4.8). These proportions suggest short cow-life times in the herd.

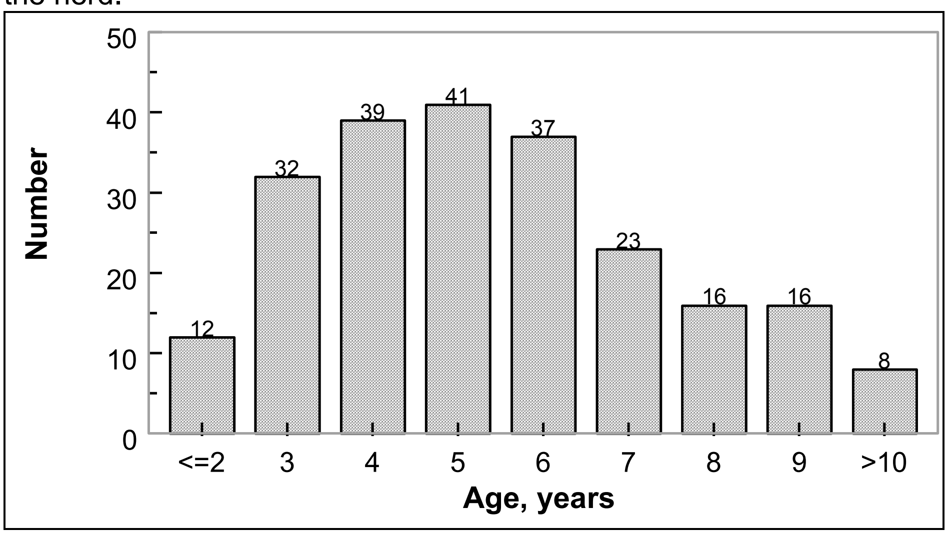

Figure 4.8 The age distribution of the post-weaner female dairy cattle

The dynamic nature of these smallholder herds is also apparent from the herd changes reported by the survey respondents over the previous 12 months (Table 4. 10). In the preceding year, 265 animals had left the aggregate herd, of which about half had been sold, while 177 had entered the herd, of which 72% were births. The net change was therefore a loss of 88 animals (12%). Noteworthy were the net losses of cows without compensatory gain in heifers (Table 4.10). In fact the net entry of female calves and heifers amounted to only about half of the net exit in numbers of cows. Overall, there was a reported net loss of 11% in the numbers of females. This change may not be statistically significant given the total number of females (585), but suggests that the number of females is either stable or declining.

The 14 % decline in the number of males, however, is likely to be significant, and points towards the effects of continued intensification of dairying over beef, as farmers focus resources on milk-producing animals, leading to a decline in the proportion of males in the overall herd. Nevertheless, purchases of post-weaner males (7 reported) suggests that some farmers continue to raise males for slaughter and/or reproduction.

Contributing to the cow exits was the fact that as many cows were reported as having died as sold, yielding an overall cow annual mortality rate of 11%. Although changes in animal type during the 12 months reported, (e.g. from pre-weaner to heifer) would affect the accuracy of the figures, the reported deaths indicate a calf (pre-weaner) mortality rate among females of 18%, with double the figure reported for males, as might be expected given differences in rearing attention. Also, as expected, sales of male animals were proportionally higher than those of females.

These results, if borne out over time and over larger areas of the dairy-producing region, suggest potentially serious consequences for the national dairy herd, or at least that part of it in the most intensive highland areas. It may also represent a shift of dairying to less densely-populated areas. Further research is currently being conducted by MoA/KARI/ILRI to explore these trends in more detail.

Ruminant herd size: Mean cattle herd sizes and farm ruminant holdings can be compared following conversion to TLU.[5] Mean cattle herd TLU was highest for the coffee zone, 1.87, and lowest for the tea zone, 1.36, with the horticulture zone intermediate with a mean of 1.49 TLU. Within the coffee zones, cattle herds on coffee-growing farms were larger, 2.11 TLU, than those on farms without coffee, 1.69. When the TLU values for small ruminants were included in the calculation, the highest mean herd/flock ruminant TLU was for the coffee-growing farms in the coffee zone, 2.25. The contribution of small ruminants to ruminant TLU was particularly marked on farms without tea or coffee in the tea zone.

[5] When calculating Tropical Livestock Units (TLU), the conversion factors used were:

Animal class	Cattle	Goats	Sheep
Adult male	1.0	0.1	0.1
Adult female	0.7	0.1	0.1
Weaners	0.5	0.07	0.07
Pre-weaners	0.2	0.03	0.03

Table 4.10 Aggregate changes in herd composition reported over the previous 12 months by the survey respondents.

Changes	Females				Males					
	Cows	Heifers	Pre-weaners	Total	Bulls	Castrates	Post-weaners	Pre-weaners	Total	Overall Total
Births	0	0	53	53	0	0	26	41	67	120
Purchases	31	16	0	47	3	0	7	0	10	57
Total Entries	31	16	53	100	3	0	33	41	77	177
Sold	49	34	1	84	48	2	22	3	59	143
Died	47	13	8	68	11	0	6	16	33	101
Slaughtered	11	2	0	13	4	0	2	2	8	21
Total Exits	107	49	9	165	63	2	30	21	100	265
Net Change	-76	-33	44	-65	-60	-2	3	20	-23	-88
Herd at Survey (6/96)	367	174	44	585	33	4	91	41	166	751
% Net Change	-21%	-19%	100%	-11%	-182%	-50%	3%	49%	-14%	-12%
% Annual Mortality Rate	11%	7%	18%	11%	14%	0%	20%	36%	17%	28%

4.9 Feed Resources and Production Practises

In the coffee and horticulture zones, more than 75% of households exclusively stall fed their cattle, a practise consistent with the small farm sizes in those zones (Table 4.6). By contrast, in the tea zone where farms are on average larger and some smallholders have access to common lands (including forest reserves), more than half grazed their herds (Table 4.11). Whereas now 67% of households stall feed their dairy cattle, ten years ago only 47% were stall feeding, while the proportion practising grazing has almost halved in ten years, from 51% to 28%. This is clear evidence of increased intensification of the farming practices in the area in general, and of intensified dairying as an important part of that change.

Table 4.11 Main feeding system practised by households with cattle, by land-use zone (%).

	Land-Use Zone			
Feeding System	**Tea**	**Coffee**	**Horticulture**	**TOTAL**
Stall feeding	42	85	76	67
Both	6	2	3	5
Grazing	52	13	21	28

Although stall feeding is generally predominant, even on the farms where cattle were grazed, sometimes referred to as “semi-zero grazing” farms, their pastures were not usually the main source of feed. Rather it was fodder (including crop residues) gathered from the farm (56% of respondents reporting main source of feed), or purchased (20%) and fodder collected from public land (10%), which were the main sources of feed. Napier grass was grown by nearly 70% and maize by over 80% of semi-zero grazing farms. Few fed agro-industrial by-products such as maize bran, although 70% used commercial concentrates. Feed shortages were experienced seasonally by 60% of semi-zero grazing farms.

Of the farms practising zero-grazing, nearly half (46% of respondents) reported purchased fodder as their main source of feed, a third (35%) fodder from their own land and 13% (one in eight) fodder gathered from public land. Nearly three quarters grew napier grass and over 90% maize. And, in common with the farms practising grazing, agro-industrial by-products were not a frequent main source of feed, yet over 70% used commercial concentrates. Nearly 70% of farms practising zero-grazing experienced feed shortages seasonally.

Feeding practises have changed over the last 10 years; for example, Figure 4.9 shows that about 16% of the farmers reported using concentrate feeds now who did not 10 years ago, 13% are now using minerals, 11% poultry manure, 10% wheat bran and 9% napier grass. On the other hand, there has been a shift by 36, 32 and 22% of the farmers, respectively, away from the use of roadside grass, dry maize stover and local salt (Figure 4.10).

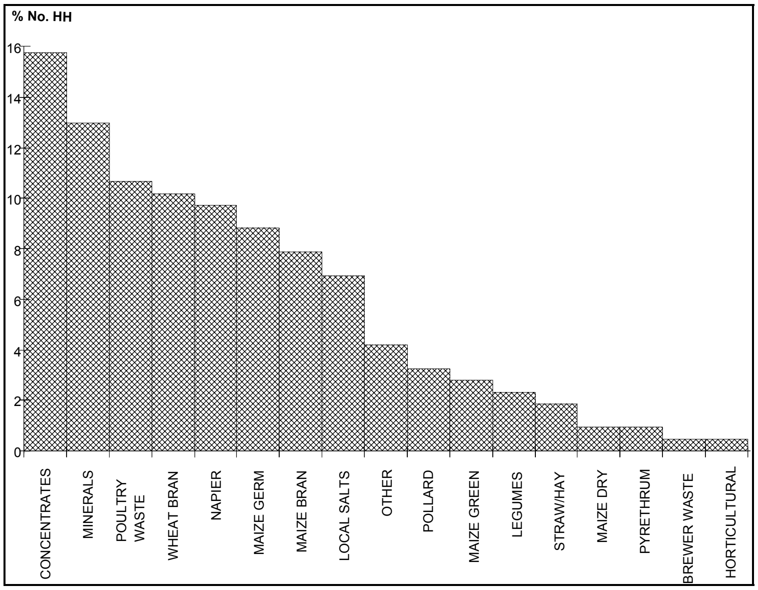

Fig. 4.9 Feeds used now and not 10 years previously

These feed resources available from outside the farm underpin the strategies of smallholders addressing seasonal feed shortages. The main strategies reported were: purchasing fodder (60% of dairy farms), purchasing concentrates (51%) and feeding fodder from trees and/or shrubs or plants not normally used as fodder (15%). Less frequently cited strategies included feeding less, reducing the herd size, and deferred cutting of one's own napier.

These results reflect an increasing dependence on purchased feeds, both concentrate and fodder, and the reduced availability of communal feed resources gathered at no cash cost. The planted forage, napier grass, has also grown in importance (the areas currently planted to various fodder sources were presented in section 4.4.3 and Table 4.6). These data support the trends in reduced grazing, and further highlight the fact that the system is intensifying. Nutrients now appear to be imported in large quantities into the overall system through concentrate and mineral purchases.

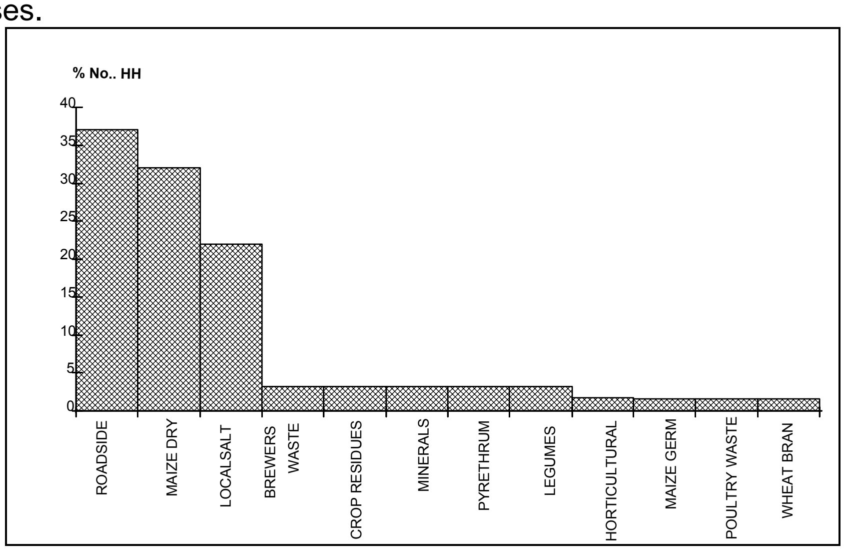

Fig. 4.10 Feeds used 10 years previously and no longer

In contrast to the almost omnipresent planted forage, napier grass, introduced forage trees and shrubs and herbaceous forage legumes were not common; fewer than 7% of dairy households reported that they grew *Leucaena spp.,* and fewer than 4% reported *Sesbania spp.* or *Calliandra spp.* Only occasional farms reported the herbaceous legume, *Desmodium intortum*, which has been recommended by the extension service for many years. A more common multi-purpose tree was *Grevillea*, a tree planted for pole production.

Farms without dairy cattle served as sources of fodder, including napier grass. For example, a quarter of the non-dairy farms surveyed in the tea zone reported selling napier grass and a third green maize stover. In the coffee zone more than one non-dairy farm in five sold napier grass, a quarter sold dry maize stover, and one farm in seven sold green maize stover. Napier grass was sold by 40% of non-dairy farms in the horticulture zone, while more than 20% sold dry maize stover.

Stall-fed cattle were generally fed as a group, and as a result specific fodder were not targeted particularly to lactating cows, for example. More farms restricted access to the trough in the horticulture zone (29%), than in the tea (19%) or coffee (8%) zones. Of the farms practising stall feeding, half in the tea zone had no roof to the stall, in the horticulture zone a third had no roof, and in the coffee zone 20% had no roof. In the tea zone over 70% of the stalls had a soil floor, while in the coffee and horticulture zones the proportion was about a half. A deep litter bedding system was used by about half the stall feeding farms in each of the zones, and more than three quarters stored the bedding and excreta before applying it to the land. In such circumstances, many of the available nutrients in faeces and urine are being lost, and much improvement in nutrient management could be made through better management of cattle excreta.

On the majority of farms water was always available to the cattle. Only in the horticulture zone were a high proportion of farms (43%) carting water; otherwise there was access to piped water or an alternative on-farm source. Over 70% of the horticulture zone farms carting water had to bring it more than 0.6 km.

Generally calves were reared by bucket-feeding, not suckling. Most (more than 90%) were weaned by 4 months of age with males tending to be weaned and sold earlier than females. Male calves were not generally castrated.

With few exceptions, the dairy cattle were milked twice daily.

4.10 Livestock Management

Credit for Dairy: Few respondents used long-term credit for their dairy enterprise, such as for cattle purchases or shed construction; a third said that they had no need of such credit and approximately half said that either it was unavailable or was too costly.

Livestock Extension: Fewer than half of the dairy farmers reported receiving livestock extension advice. The source of the extension advice was usually, and in the tea zone solely, the Government extension service.
Planted forages and cow feeding were the topics most frequently covered by livestock extensionists, followed by calf rearing and, in the horticulture zone, animal

health.

Performance recording: A minority of farms kept written records of dairy performance. Recording was most prevalent on the coffee zone, and least in tea zone. As might be expected animals were most commonly identified by name.

Table 4.12: Availability of AI and Veterinary Services: percent of dairy households reporting services available by source.

Source	AI.	Vet.
Government	14	60
Private	14	41
NGOs	1	0
Co-operative	41	25
Agrovet	0	8
Informal	0	2
Neighbour/relative	0	2
None	48	15
Total	100	100

-

Breeding management: Artificial insemination (AI) was available to more than half of the dairy farmers. Most of those used AI, while 39% of the dairy farmers reported using a bull for mating. Table 4.12 shows that a majority of these farmers received AI services from the dairy co-operatives. Most farmers indicated that they used curative veterinary services from the Government (60%) and private veterinarians (41%). Of note is the fact that overall only 52% of farms reported using AI services, meaning nearly half of the dairy farmers rely on bull service. The consequences of that level of AI use for the genotype of the overall herd is uncertain, but may lead in time to a reduction of performance.

Cattle health problems and management practises: Three quarters of cattle-keeping households reported no mortalities among their cattle during the year prior to the survey. In the coffee zone 12% of the households reported one mortality, and 18% and 21% in the horticulture and tea zones, respectively. Generally exits of animals from herds because of mortalities resulting from disease equalled those from all other causes of death or slaughtering.

Respondents stated that, in order of importance, East Coast fever (ECF), anaplasmosis, mastitis and intestinal worms were the major animal health problems they faced. In the horticulture and tea zones, respiratory infections were also reported by farmers to be important. During the last year, over 80% of cattle-keeping households in each of the zones reported having used anthelmintics, mostly as a preventive measure (Table 4.13), and three quarters in the tea and coffee zones and 60% in the horticulture zone had vaccinated their cattle.
The most frequently reported vaccination was against foot and mouth disease. Nearly three quarters of dairy farmers reported using acaricides regularly, reflecting perceived risks from ECF, a tick-borne disease.

Table 4.13: Health management practises : proportion (%) of dairy farms

Health management practise		%
Use of acaricide		71
Use of anthelmintics	Overall	89
	Curative	11
	Preventive	89
Cattle vaccinations	Overall	63
	FMD	82
	Anthrax	10
	Other	8

4.11 Dairy cattle performance

In the survey dairy herds, there was a wide range of performance around a mean that reflected low productivity (Table 4.14). The average daily milk yield in the survey sample was 7.2 litres (SD = 3.7); average calving interval, calculated retrospectively from calving dates, was 591 days (SD = 229); and, average lactation length was 388 days (SD = 256).

Table 4.14: Average milk yield, calving interval and lactation length

	n	Mean	Range
Average milk yield (litres)	202	7.2	1.0 - 24.0
Calving interval (days)	115	591	273 - 1308
Lactation length (days)	29	388	30 - 1004

Reported age at first calving ranged from less than 20 months to over 40 months, with 36% falling between 25 and 30 months (Figure 4.11).

These low milk yields, extended lactations and long calving intervals are consistent with performance when the nutrition of lactating cows is inadequate, a conclusion in line with the feed shortage constraints reported by the majority of dairy-cattle owning households in the survey. This conclusion, that inadequate nutrition is depressing milk yields and reproductive performance, is further supported by the rapid descent of the lactation curve constructed from the reported milk yields (Figure 4.12).

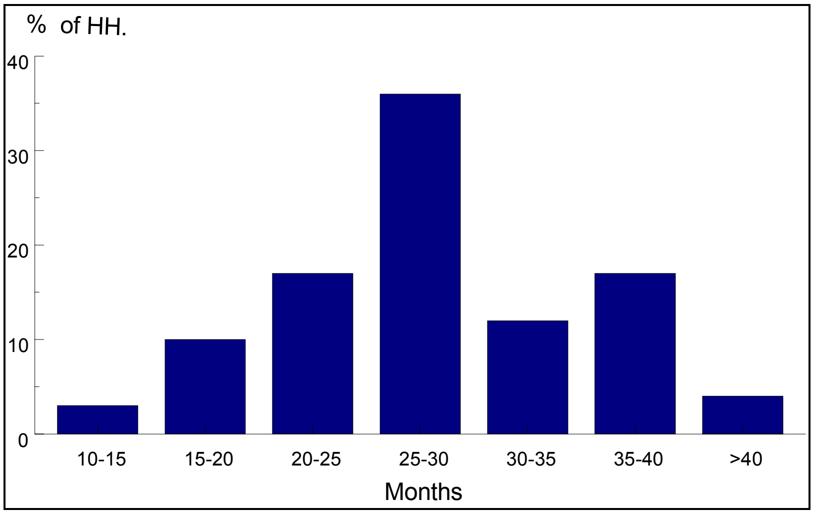

Fig. 4.11 Age at first calving

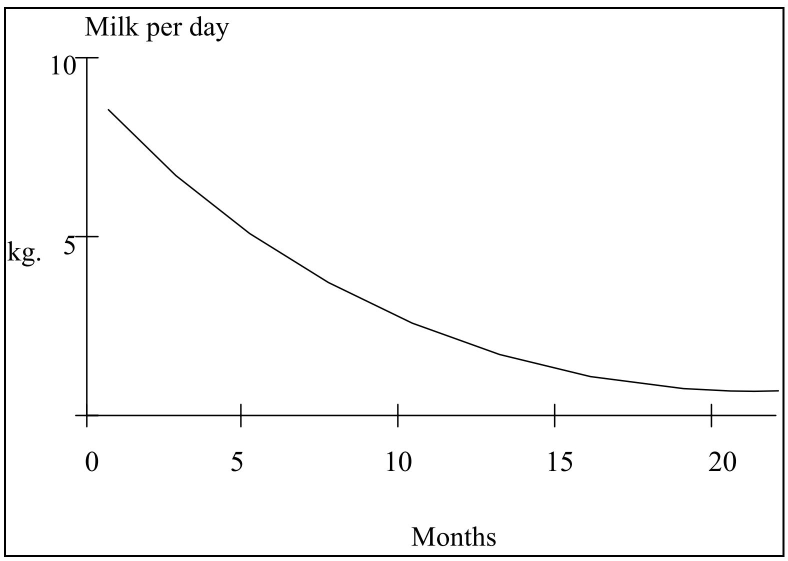

Fig. 4.12 Lactation curve estimated from pooled Kiambu data, semi-log linear functional form.

An estimate was made from the data of a semi log-linear lactation curve with functional form:

$$y = \alpha + \beta_1 \ln (x_1) + \beta_3 x_2 + \beta_3 x_3$$

where y is milk yield per day, x_1 is months, x_2 is parity number, x_3 is genotype (1= local, 2= cross-bred, and 3=high grade). This 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). The data, amounting to 543 observations, was pooled and the specified functional form was estimated. Other functional forms, including Morant's, linear, quadratic and cubic equations were estimated, but yielded no explanatory power as measured by R^2.
Estimates of semi log-linear function:

$y = 8.359 - 2.48 \ln x_1 + .377 x_2 + .94 x_3$

n= 543, adjusted R^2 = 0.294

As estimated, all of the parameter estimates for the variable are strongly significant, as seen in the results below (Table 4.15).

Table 4.15 Parameter estimates of the level of significance for each variable

Variable	Parameter Estimate	Standard Error	t ratio	Prob > |t|
y (milk yield)	8.359237	0.84513408	9.891	0.0001
x1 (months)	-2.480642	0.17262990	-14.370	0.0001
x2 (parity)	0.376682	0.11079341	3.400	0.0007
x3 (genotype)	0.940011	0.32161133	2.923	0.0036

The absence of a lactation peak and the rapid decline in daily milk yield over the early months of lactation strongly suggest that feeding levels to lactating cows, particularly during the first months of lactation, are low. This major constraint to efficient milk production is an important opportunity for improving the productivity and the profitability of the majority of smallholder dairy herds in this survey.

4.9 Access To Market

The average distance of the farms from Nairobi was 35 km (SD = 16; range = 4-76); a third of the households were less than 25 km from Nairobi, half between 26 and 50 km, and fewer than 20% were more than 50 km. The average distance to a market or trading centre was 2.3 km, with almost half the farms within 1 km and three quarters within 3 km of a market/trading centre (Figure 4.13). Most farmers in Kiambu District therefore have good access to local markets both for their farm produce, including perishable products such as milk, as well as for farm inputs. In addition they are within easy reach of Nairobi.

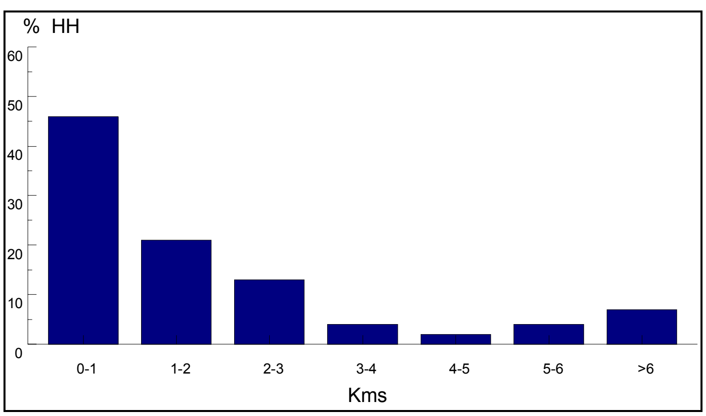

Fig. 4.13 Distance of farms to market/trading centre.

Access to markets was facilitated by the relatively short distances from the farms to an all-year passable road (mainly good murram or graded soil roads). The average distance was 2.4 km with three quarters of farms within 3 km of an all-year road (Figure 4.14).

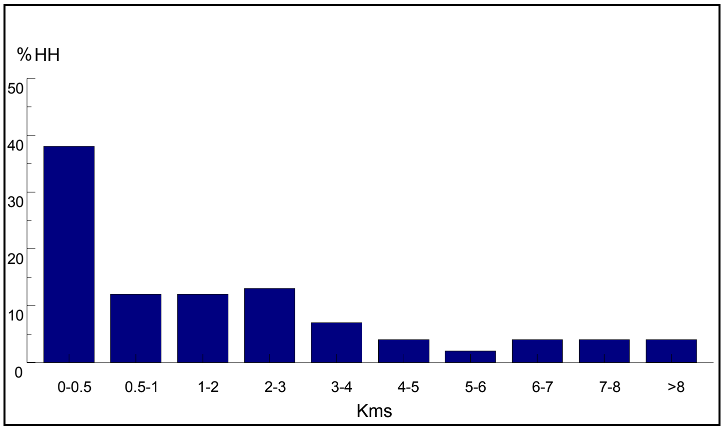

Fig. 4.14 Distance of farms to road open all year.

4.10 Milk Marketing

In the analysis of the primary outlets reported for milk produced by the households, a quarter of dairy households reported having no surplus milk to sell; nearly 20% sold mainly to individuals locally; 10% to itinerant milk traders; and, almost half sold primarily to dairy co-operative societies (Figure 4.15). The average quantity of milk sold during the dry season when the survey was conducted was 7.6 litres per day at an average price of Ksh. 13.40.

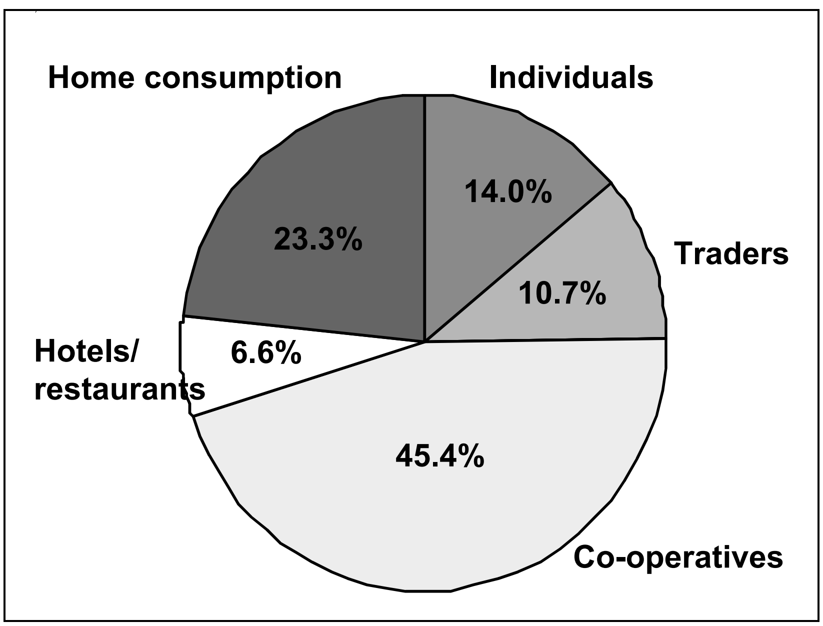

Fig. 4.15 Primary milk outlets; % of Households

The role of dairy co-operative societies for the marketing of milk is reflected in the proportion of dairy households, 59%, being registered members of a dairy co-operative society. Of these registered members, 68% were active members, i.e., were delivering milk to the co-operative. This shows, however, that only some 41% of dairy producers reported being active members of dairy co-operatives. Dairy production is thus not necessarily closely linked to the formal market, here represented by dairy co-operatives. Non-members reported selling on average 6.6 lt/day, while co-op members reported selling 8.2 lt/day. Prices received in the informal market, however, were higher, as non-members reported receiving on average about 1 Ksh more per litre.

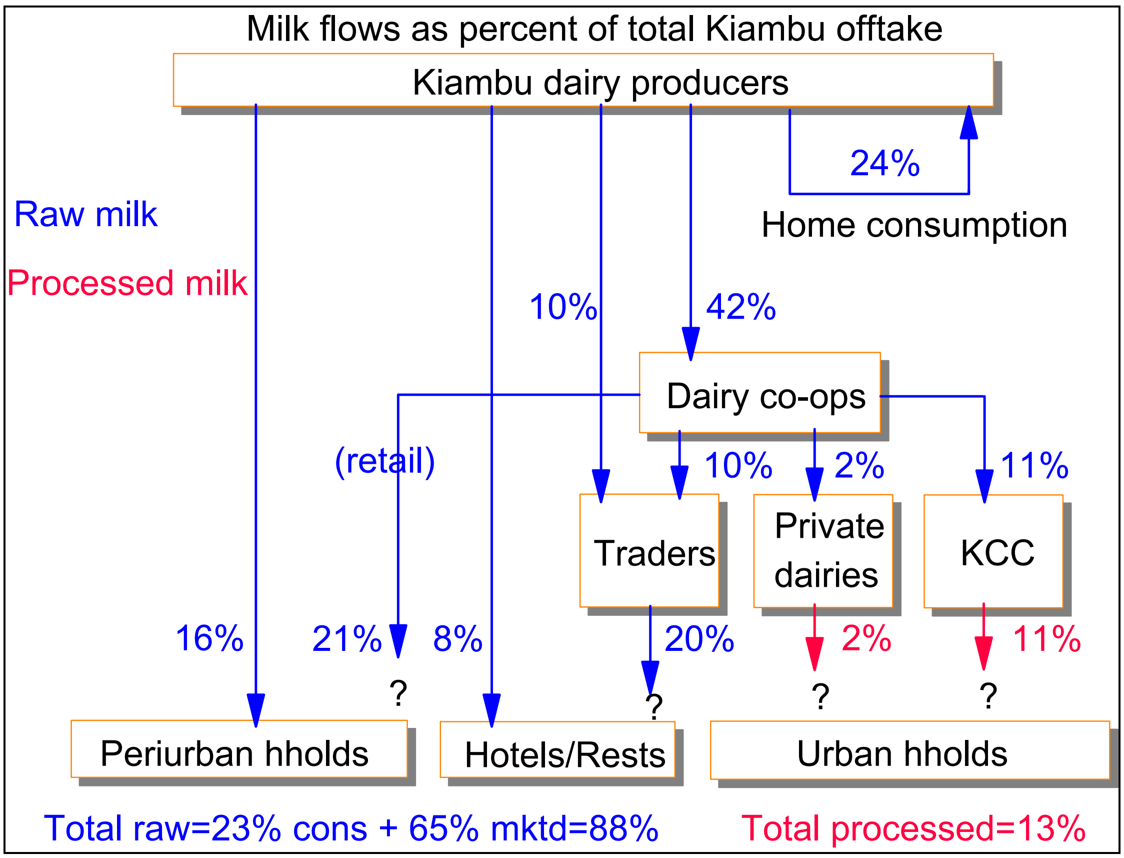

Fig. 4.16 Estimated proportional milk flows through alternative market channels, Kiambu

The data gathered were combined with data from a study of dairy co-operatives in 1995 (Owango et al, 1998) to calculate the relative proportions of milk in the alternative milk market channels available to producers in Kiambu. The results, shown in Figure 4.16, show clearly the importance of the informal milk market in this peri-urban area. Most milk is marketed as raw milk (88%), in spite of the role of dairy co-operative societies.[6]

That is because, besides the milk marketed directly by producers to consumers,

[6] These figures combine data gathered during the characterisation survey with those collected in 1995 by KARI/ILRI, and reported in Owango et al, 1998.

dairy co-operatives market some 68% of their milk either directly to consumers from their premises, or to traders who then market the milk raw to consumers. The milk eventually going to the KCC only comprises some 11% of the total milk marketed in Kiambu. The informal market thus continues to play a critical role in serving producer needs for milk market outlets. As discussed by Owango et al. 1998, although this role may decrease with distance, the milk market liberalisation of 1992 has created an environment in which the informal milk market channels are growing, and now form the primary competition to predominance of the KCC. Other as yet unpublished research by MoA/KARI/ILRI has shown that overall in Kenya, milk reaching formal processed milk channels comprises only some 20% of market milk overall.

5. RESULTS FROM PRINCIPAL COMPONENT AND CLUSTER ANALYSES FOR IDENTIFICATION OF RECOMMENDATION DOMAINS: HOMOGENEOUS TARGET GROUPS OF DAIRY PRODUCERS

5.1 Methodology

Research aimed at developing appropriate interventions to assist smallholder dairy producers requires a clear understanding of the dairy systems of the target farmers. These systems include not only dairy technologies such as use of specific feeds or feeding strategies, husbandry practices, or breeds of animals, but also are dependent on farm/household resource constraints, as well as the market environment faced by the farm/household. Appropriate interventions should consider all of these factors, and research towards developing them should begin by identifying relationships and patterns in these factors. This is particularly important where, as has been seen in the results of the descriptive analyses, considerable heterogeneity exists among the sample population. Understanding patterns existing in this heterogeneity may be particularly important when the intention is to replicate interventions in similar recommendation domains (Gockowski and Baker, 1996).

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. This method is based on Gockowski and Baker (1996), and uses principal component analysis followed by cluster analysis. Underlying this combined method is the desire to reduce the number of variables used in the clustering without omitting potentially important information (variation). Traditional clustering methods require the selection of a few variables considered to be centrally important to differentiating the household sample, and clustering the observations around the variation in that group of variables. With the addition of more variables to the cluster analysis, the difficulty of sensibly interpreting the cluster results grows geometrically. Using fewer variables, on the other hand, increases the chance of not including variation important towards explaining patterns in the farm/households. 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. A similar method was applied by Carter (1997) in Western Kenya to spatial rather than household data.

The process thus consists of two steps:

- principal component analysis of several sets of original farm/household variables to identify, within the vector space formed by those variables, new vectors along which most of the variation is observed to occur, and which number fewer than the original variables, and

- the farm/households are then scored along the new vectors, and those created variables are used in a standard cluster analysis.

This combined approach allows the variation obtained from a larger set of variables to be synthesised into a more compact cluster analysis.

5.2 Identification of principal components

Given a matrix of farm/household variables **X** = (X_1, X_2, ..., X_n) with positive definite covariance matrix var(**X**) = **S**, principal components can be identified through linear combinations $Y = a_1X_1+a_2X_2+...a_nX_n$. This is done by finding arbitrary values of the matrix of coefficients **a**=(a1,a2,..,a_n) such that the variance of Y is maximised, where var(Y) = var(**a'X**) = **a'Sa,** and where **a** is normalised so that **a'a** = 1. The first principal component then corresponds to the normalised characteristic vector $\mathbf{a_1}$=(a_{11},a_{12},...,a_{1n}) associated with the largest characteristic root of **S**. Subsequent principal components are found in a similar step-wise fashion, subject to the additional restriction of zero covariance with previous components. The proportion of total variation associated with each principal component is thus largest for the first, and successively smaller for the 2nd, 3rd, etc. (Gockowski and Baker, 1996). In the SAS FACTOR procedure used to carry out this analysis, the original variables are standardised to unit variances and mean 0, in which case the covariance matrix yields simple correlations instead of covariances. The resulting values of a_{ij} are thus simple correlation coefficients between the original variables $\mathbf{X}_i$ and the principal component $\mathbf{Y}_j$, and when interpreting the results, can be used to determine the relative importance of the original variable to that principal component. To assist interpretation, the resulting principal component vector, or factors, can be rotated, which can yield more meaningful patterns without altering the statistical explanatory power of the factors. If rotated orthogonally, the factors remain uncorrelated. Standardised scoring coefficients are also produced by the procedure, so that individual household observations can be created along a new variable composed of the linear combination of 1st principal component scores multiplied by original variable values, for example, so that the new variable has variance of 1 and mean 0 (SAS, 1987).

5.3 Selection of variables used in principal component analysis

The groups of variables used in the principal component analysis were selected *apriori* 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:

- the level of intensification of the farm dairy system,
- the farm/household resources available, and
- the 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 considered to be 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 such activity 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.

These three themes thus form the conceptual framework used in the principal component and cluster analysis. For each theme, a set of variables considered to reflect the primary measures of variability within that theme, was chosen.

5.4 Principal component analysis by level of intensification

Measures of the level of intensification of the farm dairy system were considered to be centred around the amount of purchased feeds, and the amount of feed available from own land resources. The variables chosen to reflect own feed resources were acres of maize planted per unit of dairy cattle, acres of napier planted per unit cattle, and total household land available per TLU. Land available can be considered a measure of availability of gathered fodder, pasture, etc. Measures of purchased feeds are the amount of fodder and concentrate purchased per unit cattle. The obvious measure of intensification, milk produced per acre, was not used since it was found to be closely related to land and number of cattle, which are already represented. These variables and their means are shown in Table 5.1. To obtain complete data for all the variables used in the principal component analysis, the number of dairy household observations (261) is reduced to 172.

Table 5.1 Variables selected to indicate level of dairy intensification in the Principal Component Analysis and their means and standard deviations

Name	Description	Mean (n=172)	Std dev
MAIZ_CAT	Acreage of maize planted per TLU of dairy cattle	0.28	0.29
NAP_CAT	Acreage of napier acreage planted per TLU of dairy cattle.	0.36	0.49
CONC_CAT	Concentrate feed purchased, in Ksh, per TLU of dairy cattle	6,272	6,038
FODD_CAT	Fodder purchased, in Ksh, per TLU of dairy cattle	1,145	1,985
LAND_LIV	Total household land in acres per TLU of livestock	1.77	1.77

Following the method described above, principal component analysis was carried out on this set of five variables, using data from the 172 dairy household observations for which data were complete. Table 5.2 shows the resulting five principal components, with associated eigenvalues and contributions to variation in the five variables.
Gockowski and Doyle (1996) suggest that a common rule of thumb for selecting significant principal components is to consider those with eigenvalues of greater than one. If less than one, they can be alternatively chosen by reference to significant gaps between them. Based on these rules of thumb, the first two principal components were selected, and then rotated orthogonally to improve interpretability.

Table 5.2 Principal components associated with level of intensification

Prin Comp (#)	Eigenvalue (λ_i)	Total variation (%)	Cumulative variation (%)
1st	2.2687	45.4	45.4
2nd	1.0071	20.1	65.5
3rd	0.9411	18.8	84.3

4th	0.4775	9.6	93.9
5th	0.3056	6.1	100

The first principal component exhibits a large eigenvalue, and alone explains 45% of the variation. The first two principal components, or factors, together explain 66% of the total variation existing in the chosen variables. The rotated correlation coefficients of these factors on the original variables are shown in Table 5.3. Since the variables were standardised in the analysis to have mean 0 and unit variance, a correlation coefficient or weighting of 1 indicates strong correlation, 0 is neutral and -1 shows strong negative correlation.

Table 5.3 Rotated Factor Pattern - Level of Dairy Intensification

Variable	Factor 1 OWNFODD	Factor 2 PURCFODD
MAIZ_CAT	0.69111	0.10100
NAP_CAT	0.79964	-0.07669
CONC_CAT	0.62146	0.06514
FODD_CAT	0.03193	0.99525
LAND_LIV	0.87206	-0.01244

These results reveal two distinctive patterns of variation in intensification among the households sampled. The first factor is heavily weighted according to the acreage of napier planted, the acreage of maize planted and the land held by the household. It is also correlated with the amount of concentrate purchased per animal unit. This factor thus defines a new variable, arbitrarily called OWNFODD, which can be considered an index of the level of use of fodder produced on the farm, and more generally an index of level of intensification of use of own land and fodder resources. The correlation with purchases of concentrate cannot be easily explained, but may be related to wealth, which should become apparent with clustering with subsequent resource factors.

The second factor is essentially neutral with respect to all variables except purchase of fodder, with which it is almost perfectly correlated. This new variable, PURCFODD, thus represents another axis of variation separate from the first, which is focused on the level of use of purchased fodder. Completing this analysis, each of the 172 households was given a score along these two new variables, which consisted of the sum of the products of the weightings above and their scores along the original 5 variables.[7]

5.5 Principal component analysis by level of household resources

The same procedure was applied 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, and the total land held by the household. These variables are described in Table 5.4.

[7] To standardise the new variables, the weightings were modified slightly from the correlation coefficients by the SAS procedure, without altering the relative patterns.

Table 5.4 Variables selected to indicate level of household resources in the Principal Component Analysis and their means and standard deviations

Name	Description	Mean (n=172)	Std dev
FEMHEAD	Whether household is female-headed, 1=yes, 0=no	0.27	0.47
OFF_ADT	Proportion of adult (>16yr) hh members who work primarily off-farm.	0.31	0.31
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.	2.80	1.43
TOTLAND	Total acres of land held by household	2.93	2.56

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.

Table 5.5 Principal components associated with level of household resources

Prin Comp number	Eigenvalue	Total variation (%)	Cumulative variation (%)
1st	1.4234	35.6	35.6
2nd	0.9973	24.9	60.1
3rd	0.8763	21.9	82.4
4th	0.7030	17.6	100

The results of the principal component analysis are shown in Table 5.5. Complete data were available from 172 dairy farm/households. The analysis in this case yields one factor with an eigenvalue of over 1, which alone explains 36% of the variation in the selected variables. This factor was thus retained and the correlation coefficients with the original variables are shown below (Table 5.6).

Table 5.6 Rotated Factor Pattern - Level of Household Resources

Variable	Factor 1 WEALTH
FEMHEAD	-0.39217
OFF_ADT	0.46659
INCOME	0.68683
TOTLAND	0.76165

The factor identified by the principal components is seen to be strongly correlated with both income and total land holdings, is also positively weighted by proportion of household adults working off-farm, and negatively correlated with female-headedness. This factor was thus identified as being an index of wealth of the farm/household, and so was given that name. This association of off-farm employment and income has been shown in previous studies to be important to dairy intensification (Kaguongo 1996), particularly through its effects on increasing the availability of working capital.

5.6 Principal component analysis by level of market access

The final step of the principal component analysis procedure was to apply the procedure to the group of variables selected as indicators of market access. These included distance of the farm from Nairobi, the availability of co-operative AI services, the farm-gate price of milk received by the farm, co-operative membership, and milk sales to informal market outlets. The variables are described in Table 5.7. The study of Owango *et al* (1998) showed that co-operatives which supply AI services are likely to be among the more successful, complete-service co-operatives. Availability of co-operative AI can thus be considered a proxy for quality of co-operative services available. Use of non-co-operative market outlets (considered informal, because nearly all non-co-operative outlets serve the raw milk market) is an indicator of market development and thus output market access. Co-operative membership is an indicator of access to both input and output markets. Complete data were available from 172 dairy farm/households.

Table 5.7 Variables selected as indicators of market access in the Principal Component Analysis and their means and standard deviations

Name	Description	Mean	Std dev
DISTNBI	Distance to Nairobi, in Kms	36.95	16.52
AISCOP	Availability of co-operative AI services (1=yes, 0=no)	0.45	0.50
DDFRPRC1	Average price received per litre of milk in most recent dry season Ksh.	13.24	2.15
COOPMEMB	Co-operative membership: 1=yes, 0=no.	0.65	0.48
INFRMKT	Reported milk sales to non-co-operative outlet in last 12 months, 1=yes, 0=no	0.51	0.50

The results of the principal component analysis for market access, shown in Table 5.8, reveal one very significant factor which alone explains 47% of the variation in the five selected variables; it has a large eigenvalue of 2.4. No other factors had eigenvalues greater than one. This factor was thus the only one retained. The factor loadings against the original variables are shown in Table 5.9.

Table 5.8 Principal components associated with market access

Prin Comp number	Eigenvalue	Total variation (%)	Cumulative variation (%)
1st	2.3808	47.6	47.6
2nd	0.9816	19.6	67.3
3rd	0.7051	14.1	81.4

4th	0.5874	11.8	93.1
5th	0.3451	6.9	100

The coefficients of this factor show strong correlation with distance to Nairobi, co-operative AI services and co-operative membership. They indicate strong negative correlation with farm-gate milk price and participation in the informal, non-co-operative output market. The new variable defined by this factor, called COOPPART, is thus an index of level of association with formal, co-operative based input and output markets.

Table 5.9 Factor Pattern - Level of Market Access

Variable	Factor 1 COOPPART
DISTNBI	0.68128
AISCOP	0.64830
DDFRPRC1	-0.58873
COOPMEMB	0.76876
INFRMKT	-0.74748

As suggested by the correlation with distance to Nairobi, co-operative participation has been previously shown to increase with distance from the urban market, where market alternatives are more limited (Owango *et al*, 1998). This variable can thus be also considered a negative index of access to milk markets. This variable was also included in the cluster analysis.

5.7 Cluster analysis using the new variables

Cluster analysis was then carried out using the variables described above, which were considered to contain most of the variation relevant to the desired characterisation of the farm/households. The SAS procedure FASTCLUS was used, which employs a standard iterative algorithm for minimising the sum of squared distances from the cluster means. Each observation is assigned to only one cluster. 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.

The frequency of households falling in each cluster and the mean values for the variables employed are shown in Table 5.10.

Table 5.10 Frequency of households in each cluster and the mean values for the level of dairy intensification (OWNFODD; PURCFODD), household resources (WEALTH) and market access (COOPPART) variables

		Mean cluster values for variables:			
Cluster	Frequency	OWNFODD	PURCFODD	WEALTH	COOPPART
1	1	2.52	5.87	-0.16	1.16
2	4	-0.48	3.88	-1.49	-0.09
3	56	-0.28	-0.39	-0.53	0.43
4	48	-0.52	-0.07	-0.39	-1.27
5	36	0.20	-0.37	1.15	0.63
6	16	-0.02	1.35	-0.22	0.11

7	2	4.40	-0.19	3.60	1.13
8	9	2.74	-0.46	1.05	1.06

The cluster results show three large clusters containing most of the farm/household observations (clusters 3 through 5), with cluster 6 also containing a sizeable group. It should be remembered that these variables have mean 0 and variance of 1, thus negative means indicate levels lower than the overall sample means, etc. The largest, cluster 3, shows low levels of own fodder resources combined with very low levels of purchased fodder, very low levels of wealth and moderately positive levels of dairy co-operative participation. This appears to be a group of producers who may have some co-operative involvement and access to formal input and output markets, who yet are constrained by resources. We will therefore call this group of farmers the **Co-op Resource Poor** (CRP).

The second-largest group, cluster 4, exhibits even lower levels of own fodder resources, average levels of purchased fodder, low levels of wealth and very low levels of co-operative participation. This group appears to have the lowest levels of land resources, buys relatively more fodder, and operates mostly through the informal market. We will consider these to be the **Informal Resource Poor** (IRP) group of dairy farmers.

Cluster 5 farmers have above average levels of fodder resources, and high levels of wealth and formal market (co-operative) participation. We will call these the **Elite** (E) farmers, as they potentially represent the upper tier of producers, with land resources and good representation in formal market and community institutions.

Finally, cluster 6 farmers are distinguished primarily by the relatively large amounts of fodder they purchase. We will call these the **Specialists** (S), as they appear to purchase feed in order to practice specialised dairying. These general characterisations will be further detailed by examination of more of the original variables underlying the clustering.

5.8 Cluster means of original variables

Table 5.11 shows mean values by cluster for a number of the variables obtained from the farm/household survey. They generally emphasise the distinctions between the clusters. The co-op resource poor (CRP) group can be seen to be comprised 88% of co-op members, and have higher than average availability of coop services. This distinguishes them from the informal resource poor (IRP) group, only 10% of whom are co-op members, and 98% of whom participate in the informal market. The availability of coop services to them is poor. The milk price received by the IRP group is substantially higher than the other resource poor group, presumably due to better prices available in the informal market - this group also averages half the distance to market of any of the other groups.

Both of the resource poor groups are distinguished by high levels of female-headedness. Of note is the relatively high levels of purchased feeds seen in both groups. The co-op resource poor buy much higher levels of concentrates, while the informal resource poor groups buys relatively more fodder. This may be related to access to coop services by the CRP group. The productivity of the IRP group, as measured in milk per day of calving interval, is nevertheless higher than that of the CRP group, in spite of less use of concentrate feeds. The clear differences between these two groups appears to lie in their choice of input and output market, in spite of relatively similar resource endowments (although IRP group has somewhat less land). The IRP group has chosen to sell to the informal market, receive a higher milk price, and in turn forego credit opportunities. The CRP group appear to sell mainly to coops, but then are able to buy more concentrate feed. These differences, and the motivating factors determining them, will be one subject examined during the planned longitudinal survey.

Another observed pattern that needs explanation is the specialist group, who spend far more on both concentrates and fodder than any other group, in spite of average income levels. Of note is the low level of female-headedness. The management choices made by this group do not appear to be related to coop or informal market participation, as those values are approximately the mean for the overall survey.

Finally, the Elite group clearly has more land and higher levels of cash income, plants more napier and maize per animal, and as a result obtains the highest productivity per cow. This group is almost entirely made up of co-operative members, about half the adults work off-farm, and only 6% of households are female-headed. Of note are the relatively low levels of concentrate purchase, which are in the same range as the other groups, and are well below extension-recommended levels. If credit for concentrate purchase is not a constraint - given coop membership and income levels - then other reasons must explain this, perhaps related to perceived value of feeding, extension information, etc. Kaguongo (1996) points to production and market risk and being important constraints to adequate use of concentrate feeds.

Table 5.11 Means of Farm/Production, Household and Market/Institutional Participation characteristics for the major Clusters and for the total survey sample.

Cluster	Resource Poor Co-op (3)	Resource Poor Informal(4)	Elite (5)	Specialist (6)	Overall
Number of Hholds	56	48	36	16	172
Farm/Production Characteristics					
Farm size (acres)	2.24	1.69	4.94	2.04	2.93
Napier acreage	0.38	0.27	0.82	0.28	0.50
Maize acreage	0.32	0.26	0.73	0.39	0.43
Dairy cattle TLU	1.74	1.66	2.24	1.24	1.70
Farm acres per TLU	2.24	1.04	2.12	1.61	1.77
Napier acres per TLU	0.25	0.18	0.40	0.26	0.36
Concentrate purchased Ksh/TLU/yr	5,552	3,585	6,457	8,165	6,273
Fodder purchased Ksh/TLU/yr	342	998	386	3,769	1,145
Milk prod./acre of farm (lts/acre/day)	4.00	5.76	1.89	5.94	4.20
Milk prod./day of calving interval (lts/day)	4.43	5.25	6.67	5.18	5.55
Household Characteristics					
Age of hhold head	47.3	48.5	54.5	51.3	50.8
Years farm established	19.7	18.2	24.7	20.5	21.3
Years dairy experience	19.1	17.3	24.7	15.1	20.1
Female-headed (%)	32	38	6	19	27
Total hhold size	6.2	6.4	6.9	5.8	6.3
Hhold adults working off-farm (% of adults)	21	29	47	25	31
Income category	2.01	2.67	4.08	2.75	2.8
Market /Institutional Participation Characteristics					
Distance to Nairobi (kms)	40.0	24.4	43.4	38.2	36.9
Distance to market (kms)	2.99	1.45	2.38	2.36	2.25
Co-op membership (%)	88	10	94	63	65
Availability of co-op vet (%)	41	6	22	38	27
Availability of co-op AI (%)	48	4	67	63	45
Informal milk market participation (%)	30	98	31	56	51
Avg price milk dry season (ksh/lt)	12.59	14.80	12.66	12.95	13.24
Avg qty milk sold dry season (lt/day)	6.96	8.19	8.43	5.31	7.40

Table 5.12 shows the number of households per cluster by the farming system, based on the cash crops reported by the households rather than by land-use zones. Aggregating the figures in the table, about two thirds of the total of 102 households in the CRP and IRP groups report no traditional cash crop. Further, the IRP group is heavily weighted towards food crop farming only (42 of 46 total households).
The lack of coffee or tea, and subsequent non-participation in the co-operatives associated with those crops, may contribute to their low participation in dairy co-

operatives and access to formal markets and services in general.

Table 5.12 Number of observations per cluster by observed farming system

Cluster	Horticulture	Coffee	Tea
Co-operative resource poor (3)	23	24	9
Informal resource poor (4)	42	4	0
Elite (5)	12	12	12
Specialist (6)	10	3	3

The principal component and cluster analysis has identified differences in feeding strategy, land use, resource availability, and market and institutional choices. We have speculated as the causes of these differences, which suggest unobserved interactions between these or other factors. Important questions remain, however, as to the relative effects of market outlets, household resources, cash-cropping, female-headedness and co-operative membership on dairy farmer choices. Identifying and understanding these interactions will improve our ability to recommend policy and technical interventions which best alleviate the constraints. Such understanding, however, requires much closer explicit measurement of interactions, which can only be carried out through the longitudinal monitoring of selected farms from the important groups. The next phase of the research, currently being conducted collaboratively by KARI/MoA/ILRI, will achieve that end.

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