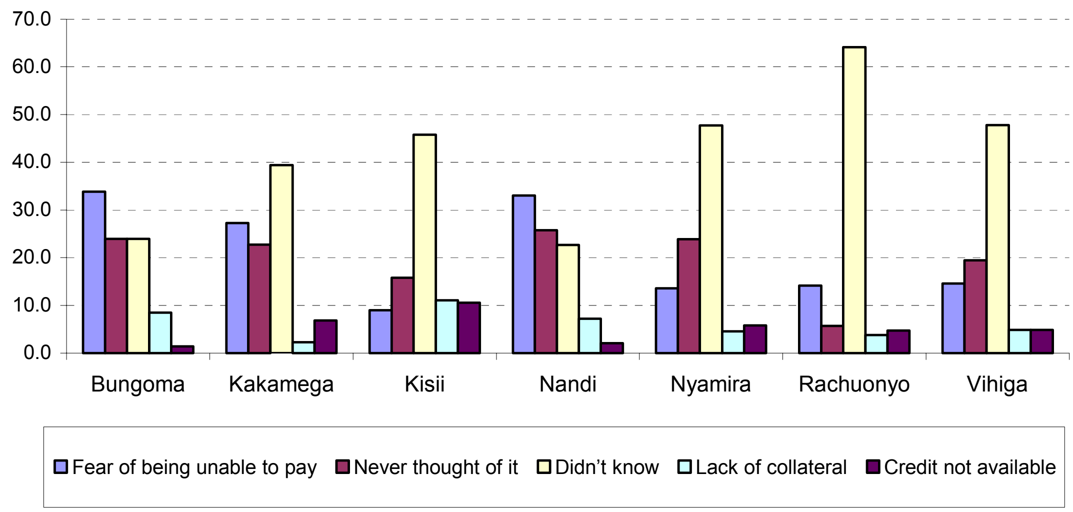
Figure 4.34 Reasons for not getting credit by district

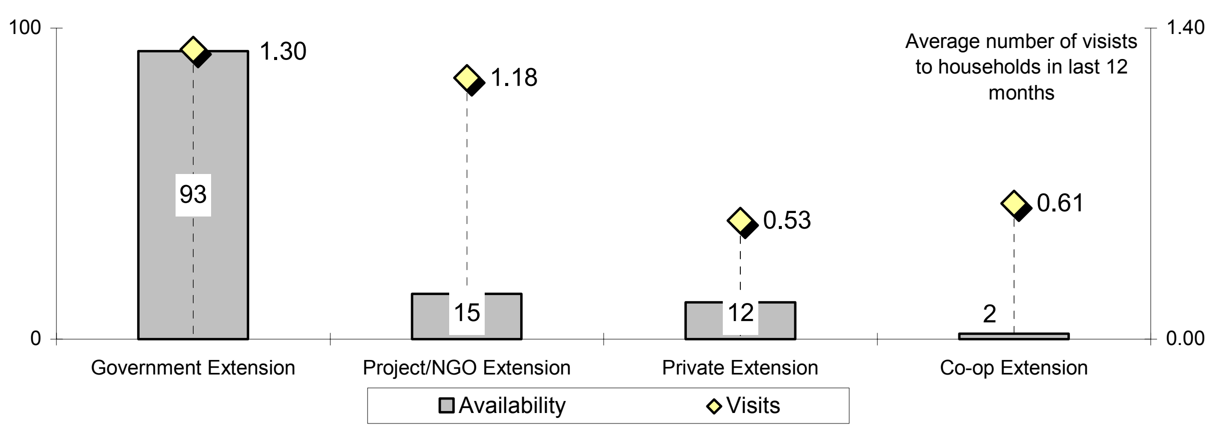


Out of 1,000 households responding to this question, only 12 indicated ever having obtained feed on credit 1 in Kisii, 4 in Nyamira, and 7 in Vihiga.

4.9.2 Extension

Ninety three percent of the households indicated availability of extension services from the government extension workers. The Project/NGO gave extension service to 15% of the households while 12% got the service from the private sector and 2% from cooperatives (Figure 4.35).

Figure 4.35 Availability of extension services and visits in last 12 months



Both government and Project extension services recorded one visit per household in the previous 12 months while private extension and cooperatives had less than one visit. The government extension services were most available, with 99% of the households in all the districts, recording an average of 5 visits per year. The Project and NGO extension services and visits were more popular in Rachuonyo (37% of the households recording 2 visits per year). The private sector gave extension service to 31% of households in Kisii and 22% in Vihiga although the number of visits was less than one visit per household per year. Farmers were not asked the number of times they have sought extension agents and also when they attend group extension activities. This might have given more information.

Food crop management and feeding of the dairy cow were the topics more frequently covered by extension. Twenty percent of the households reported that these two topics were among the top three addressed (Table 4.18). The following were the most common topics addressed by extension agents according to districts: Planting forages was 21% for households in Bungoma; food crop management 29% of the households in Kakamega, 27% in Nandi and 52% in Rachuonyo; feeding the dairy cow 20% of the households in Kisii, 27% in Nandi, 28% in Nyamira and 21% in Vihiga.

Table 4.18 Extension topics most frequently covered

	Overall	Bungoma	Kakamega	Kisii	Nandi	Nyamira	Rachuonyo	Vihiga
Planted forages	16	21	14	16	16	11	5	20
Food crop management	20	19	29	19	27	15	52	10
Feeding of the dairy cow	20	13	18	20	27	28	4	21
Health management	14	12	15	13	6	17	9	21
Cash crop management	10	12	3	11	11	10	11	9
Forage/fodder conservation	3	7	3	7	1	1	4	2
Fodder legumes	4	6	3	5	1	2	7	6
Farm management/ economics	3	4	5	3	7	6	3	0

4.9.3 Artificial insemination

Fifty nine percent of all the households in the area reported having received AI services from the government while 20% received from the private sector (Figure 4.36). The government AI services were most common in Vihiga, where 88% of the households in the district received it. Nandi had 77% and Bungoma had 74% and the lowest was Rachuonyo with 31% (Figure 4.37) receiving Government extension services. NGOs provided 5% overall and 13% in Vihiga while private sector provided 67% in Kisii and less than 1% in Kakamega and Rachuonyo. Cooperatives provided 33% in Vihiga and 17% in Nandi.

Figure 4.36 Available AI services and average visits per household in last 12 months

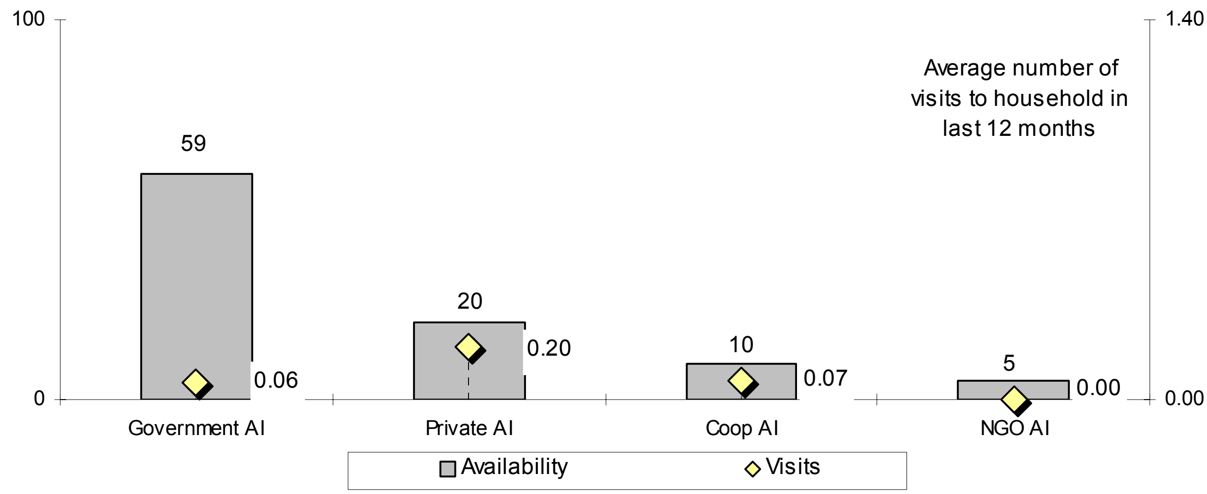
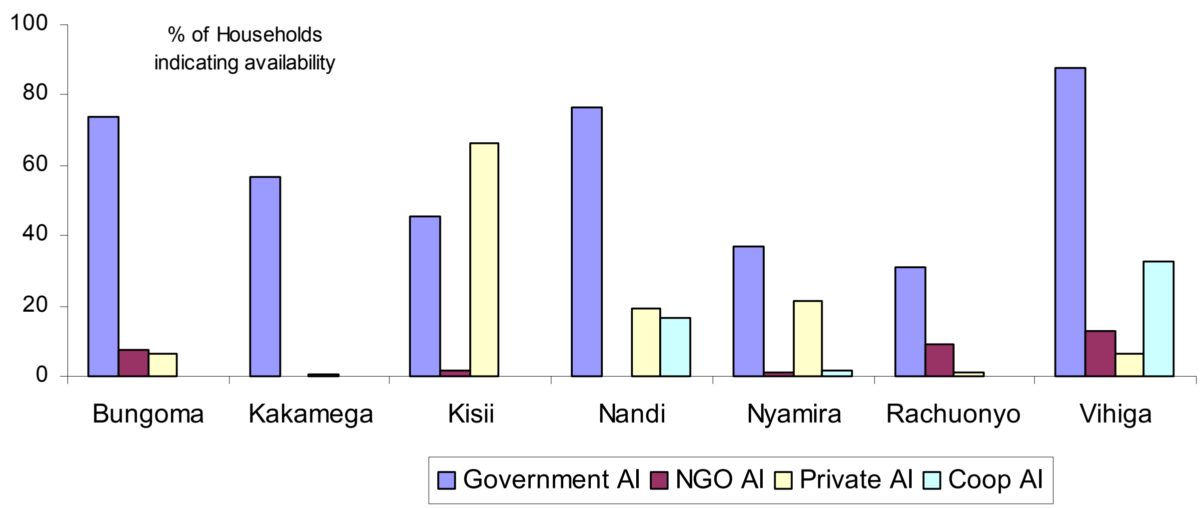


Figure 4.37 Availability of AI services by district



4.9.4 Animal health services

Among all the households in the area, the most common livestock diseases were East Coast fever, where 15% of the households mentioned the disease, and Anaplasmosis with 14% households (Figure 4.38). However there were variations in disease prevalence among the districts: 34% households in Kisii and 31% in Vihiga reported intestinal worms. Anaplasmosis was reported by 23% of the households in Rachuonyo and 25% in Nyamira (Table 4.19). 37% of the households in Nandi and 16% in Bungoma reported East Coast Fever. Finally 18% of the households in Bungoma and 14% in Kakamega mentioned the Foot and Mouth disease.

Figure 4.38 Percentage of households and three worst animal diseases

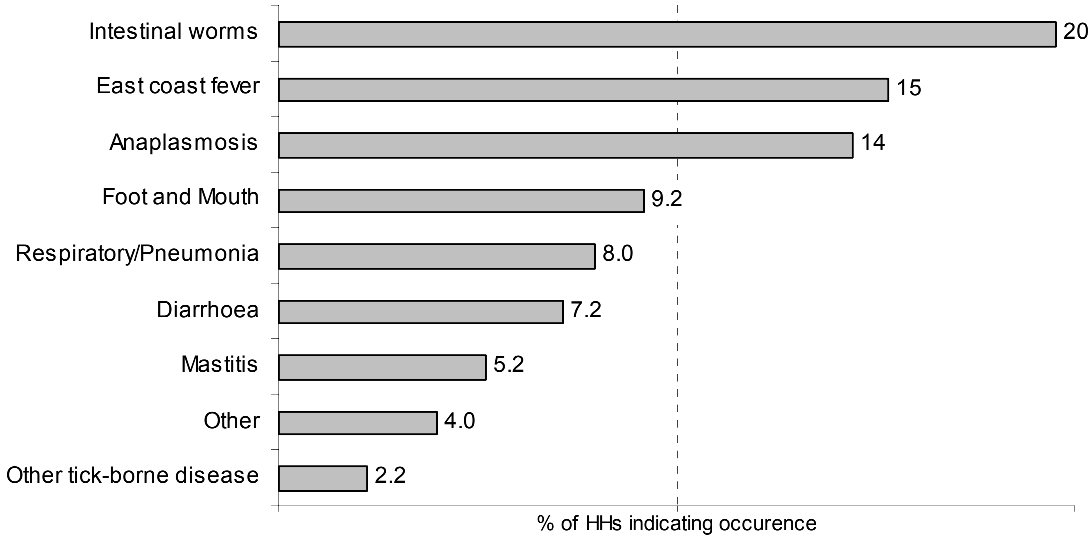


Table 4.19 Percentage of households and three worst animal diseases on farm

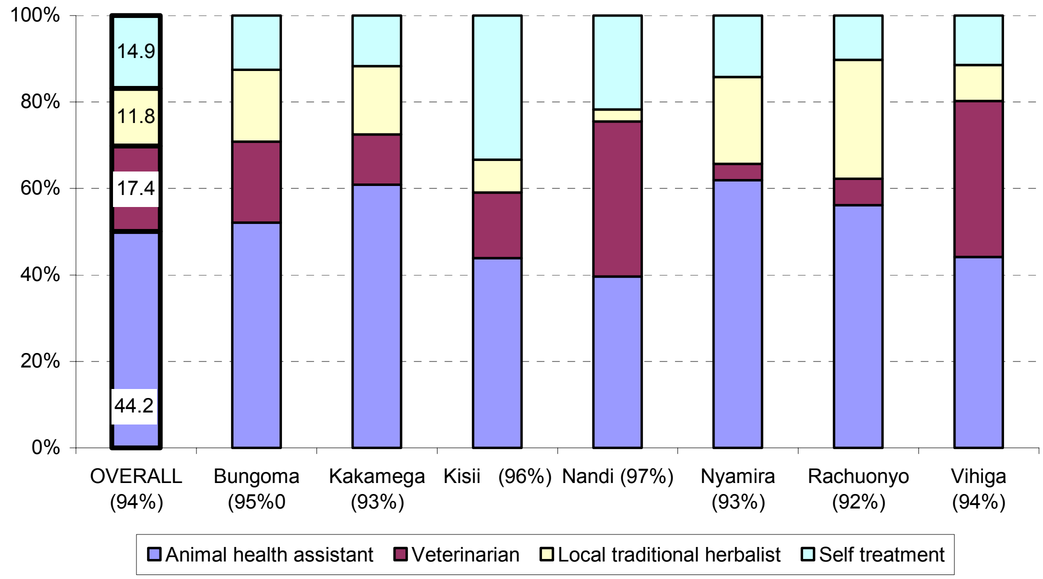
	Bungoma	Kakamega	Kisii	Nandi	Nyamira	Rachuonyo	Vihiga
Intestinal worms	6.9	12.5	34.4	6.1	16.8	10.3	31.3
East coast fever	16.4	10.3	14.8	36.7	19.4	8.4	7.6
Anaplasmosis	12.7	10.3	17.5	6.8	24.5	23.4	11.1
Foot and Mouth	17.5	14.0	5.8	5.4	5.8	15.0	5.3
Respiratory/Pneumonia	5.3	19.9	3.7	1.4	5.8	6.5	11.5
Diarrhoea	5.8	15.4	2.6	5.4	2.6	11.2	7.3

The animal health services were available in all districts with a record of 94% of the households having received these services from different sources (Figure 4.39). The animal health assistants were most popular, having given the service to 44% of the households, followed by veterinary officers, recorded by 17% of the households.

Twenty nine percent of the households in Nandi and 34% in Vihiga used animal health assistants. The use in Nyamira and Kakamega was 56% and in Rachuonyo 51%. There are some cases where households (15%) treated their own livestock without seeking external services, more so in Kisii with 31% and the rest with less than 15% cases of own treatment.

Traditional herbalists featured more prominently than veterinary officers in Rachuonyo, Nyamira and Kakamega, with 25%, 18% and 15%, respectively using herbs. Bungoma recorded 13% of the households using traditional herbalists, same proportion as those using veterinary officers (14%).

Figure 4.39 Percentage of households indicating source of veterinary services



4.9.5 Vaccinations, tick control and trypanosomosis

Sixty-one percent of households had had their cattle vaccinated in the last 12 months. However, this ranged from 38% in Kakamega to 92% in Nandi (Figure 4.40). Ninety percent of the households with cattle controlled ticks using Acaricides (Figure 4.41). Kakamega had the least percentage of households using Acaricides (78%) where some households (13%) controlled the ticks by handpicking and 6% did not carry out any control measures. Acaricides were applied by hand spraying (65% of all households), dipping (25%), or hand washing (9%). This was done once weekly in 55% of the households to both adult and young stock, once fortnightly in 17% of the households, and irregularly or occasionally in 13% (Table 4.20).

Figure 4.40 Percentage of households that vaccinated cattle in the last 12 months

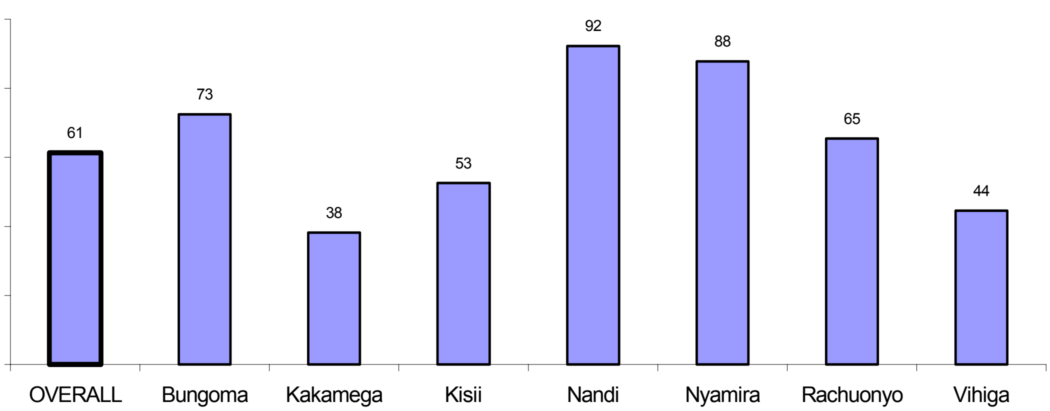


Figure 4.41 Percentage of households and methods of tick control

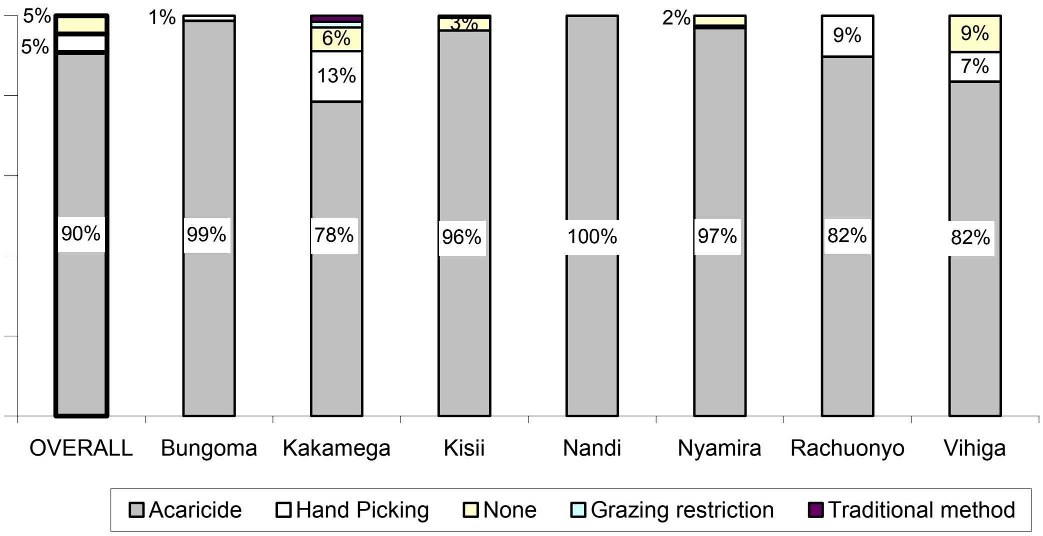


Table 4.20 Percentage of households and methods of acaricide application

Method	Overall	Bungoma	Kakamega	Kisii	Nandi	Nyamira	Rachuonyo	Vihiga
Hand spraying	65	59	75	70	30	71	78	65
Dipping	25	40	14	22	66	18	14	18
Hand washing	9	1	10	8	4	11	6	16
Pour-on							2	
Other			1			1		1

Of all the households with cattle, 4% were certain that their livestock had incidences of Trypanosomosis but 18% did not know if their livestock had ever been affected. Seventy eight percent said that Trypanosomosis was not a problem (Table 4.21). The biggest proportion of those households affected came from Rachuonyo. Trypanosomosis is a constant problem in Bungoma but with an irregular occurrence. Its presence can only be captured by a longer seasonal study.

Table 4.21 Percentage of households with a Trypanosomosis

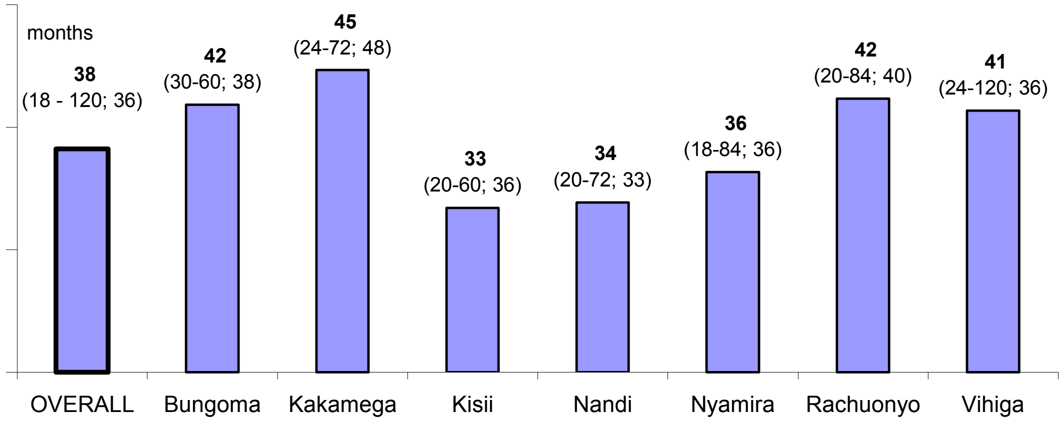
	Overall	Bungoma	Kakamega	Kisii	Nandi	Nyamira	Rachuonyo	Vihiga
No	78	76	89	78	61	77	54	92
I don't know	18	23	10	21	37	22	17	8
Yes	4	1	1	2	2	2	29	0

4.10 Dairy cattle performance

4.10.1 Age at first calving

The age at first calving was 38 months (range: 27 to 120; median 36). It was longest in Kakamega (mean 45) and shortest in Kisii (mean 33) (Figure 4.42).

Figure 4.42 Average age of cattle (months) at first calving, range and median



The age at first calving is almost uniform across all the dairy breeds (32 to 34 months) but older for zebu cows (44 months) (Figure 4.43). When comparing household categories, the mean age at first calving for dairy cows is more or less similar (mean: 33 months), regardless of the households where they were kept (Figure 4.44).

Figure 4.43 Average cattle age at first calving, range and median by breed

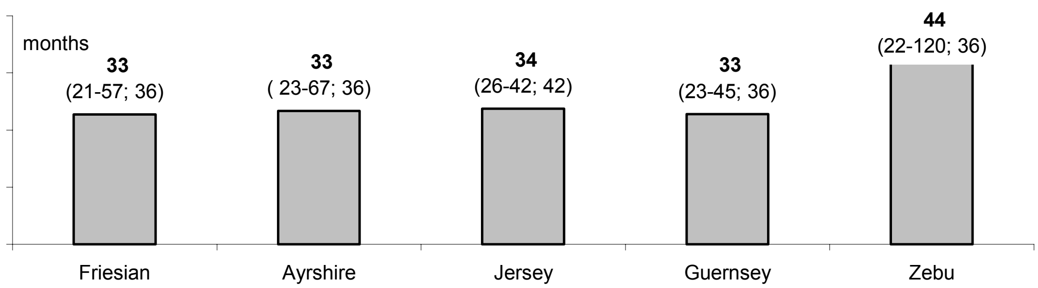
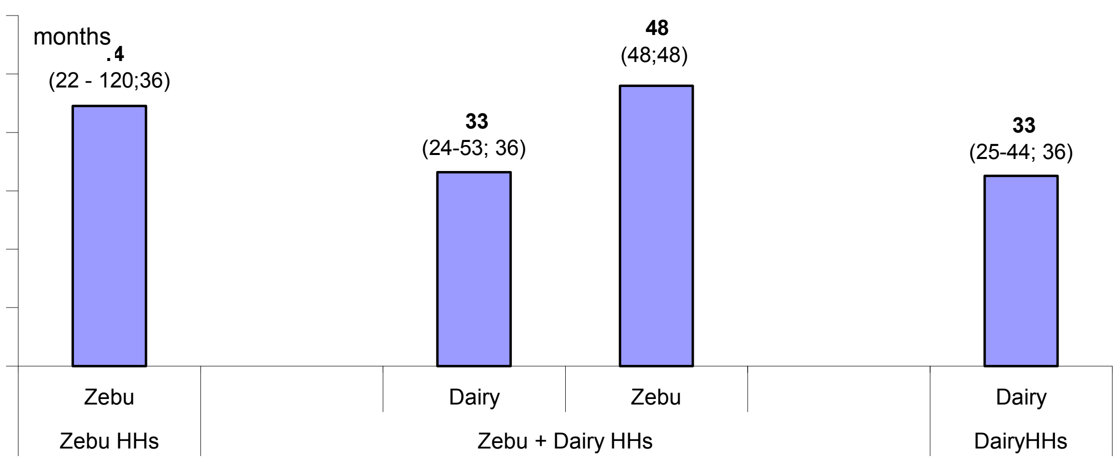


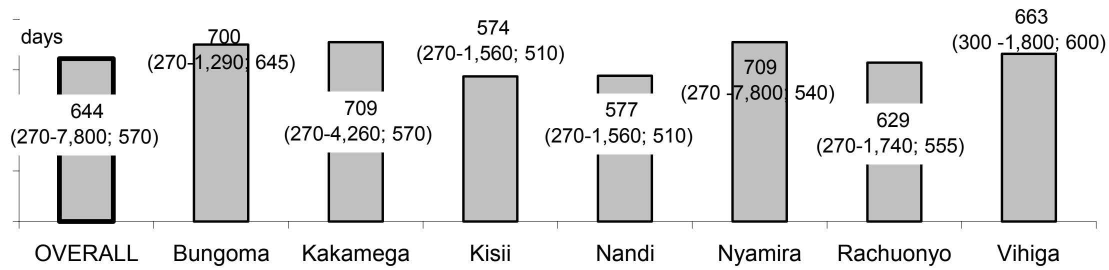
Figure 4.44 Average cattle age at first calving, range and median by household category



4.10.2 Calving interval

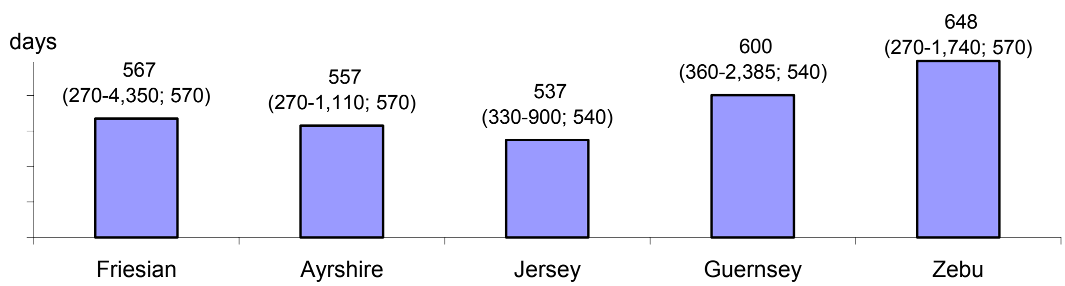
The mean calving interval was 644 days (Range 270 to 1290; median 570) for the whole area (Figure 4.45). Kisii and Nandi had the shortest intervals with means of 574 and 577, respectively and those with the longest were Kakamega and Nyamira (709 each) and Bungoma (700).

Figure 4.45 Average calving intervals by districts



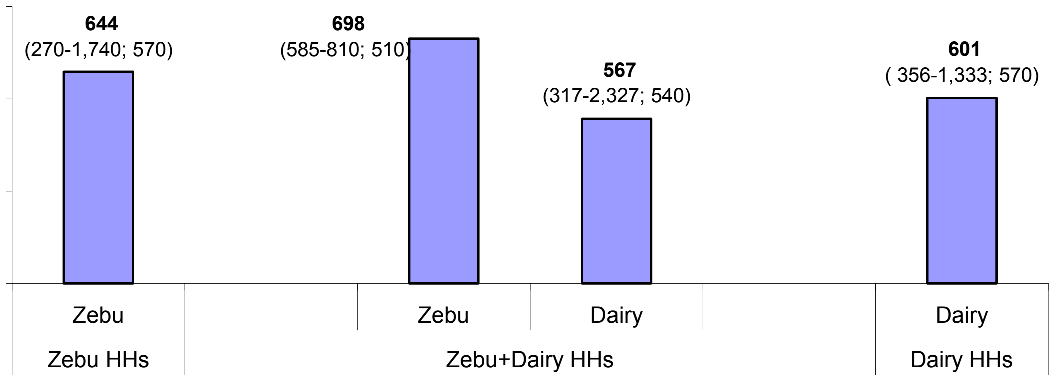
Zebu cows had a calving interval of 648 days (range: 270 to 1,740; median 570), and Jerseys recorded the shortest interval of 537 days (range: 330 to 900; median 540). Friesian and Ayrshire cows had a mean of 567 and 557, respectively (Figure 4.46).

Figure 4.46 Average calving intervals by breeds



The mean calving interval for households keeping dairy cattle alone was surprisingly longer than for those keeping zebus alone or the combination (695 versus 637 to 639 days) (Figure 4.47). The mean interval for dairy cows kept by households keeping a combination of zebu and dairy cattle was shorter (567 days) than for cows kept by households keeping only dairy cattle (601 days). The mean interval for zebu cows in households not practising any dairy was shorter (644 days) than for zebu cows in the other households (698 days).

Figure 4.47 Calving intervals by cattle types by household category



4.10.3 Milk production

This refers to average production per day along the entire lactation length, and has been worked using a model that utilizes production at calving, at mid-lactation (milk yesterday taken to be mid lactation) and at drying. Regardless of breed, cows in Kisii and Nandi showed the highest production per day (3.1 and 3.0 litres, respectively), while those in Rachuonyo produced the least (1.7 litres) (Figure 4.48).

Pure grades kept by households keeping only dairy cattle had higher production levels (5.1 litres) than those kept by households keeping a combination of dairy and zebu types (4.4 litres) (Figure 4.49), but there was no difference in the production by crossbreds in both households. Production by zebu cows in households keeping the combination was 2.7 litres, twice that of the ones kept by households keeping zebu alone (1.9 litres).

Figure 4.48 Average, maximum and standard deviation of milk production

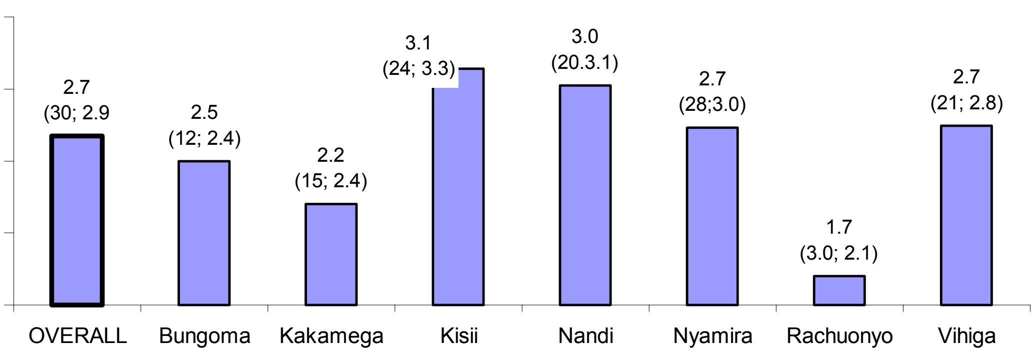
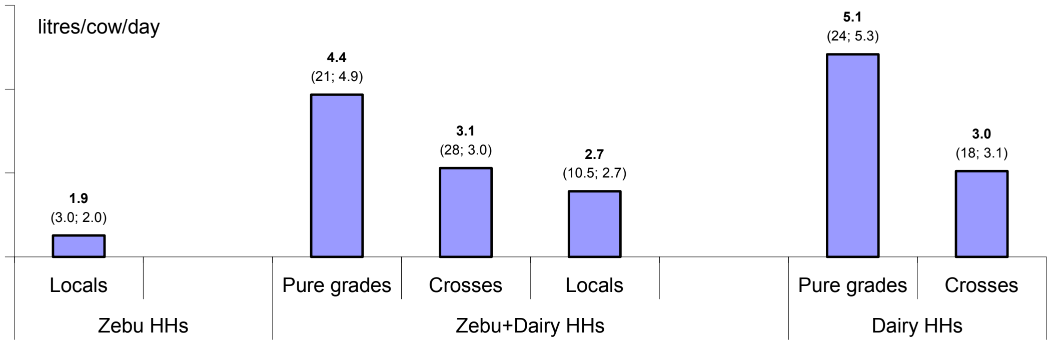
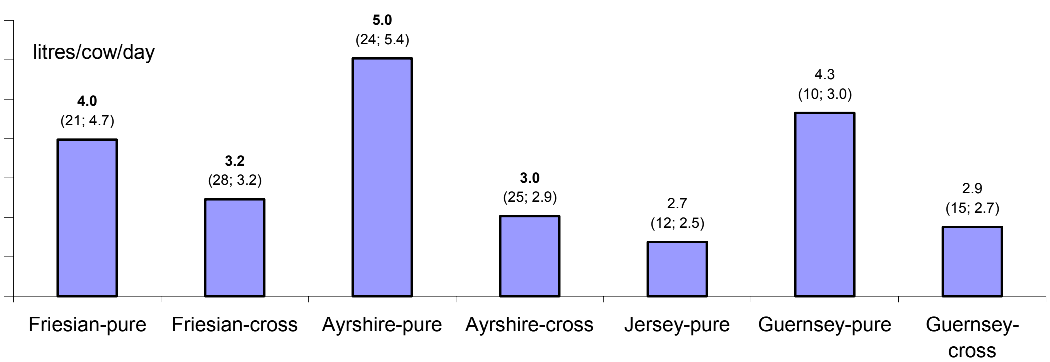


Figure 4.49 Average, maximum and standard deviation of milk production by cattle types by household category



Among the dairy breeds, production by pure Ayrshire cows (5.0 litres) and pure Guernsey cows (4.3 litres) was higher than that of pure Friesian cows (4.0 litres) (Figure 4.50).

Figure 4.50 Average, maximum and standard deviation of milk production by cattle breeds

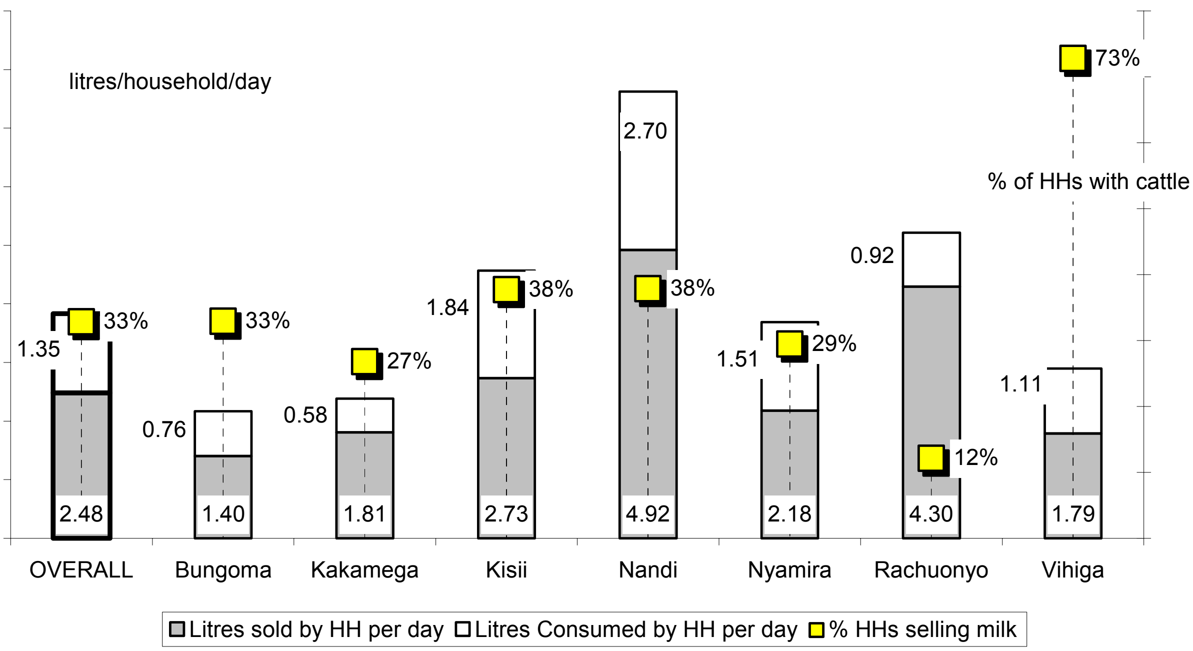


4.11 Milk consumption and marketing

4.11.1 Milk consumption

The amount of milk consumed in households with cattle was an average of 1.35 litres per day per household. It was highest in Nandi (2.70) and lowest in Bungoma (0.76) and Kakamega (0.58) (Figure 4.51).

Figure 4.51 Average milk consumption, sales and percentage of households selling milk



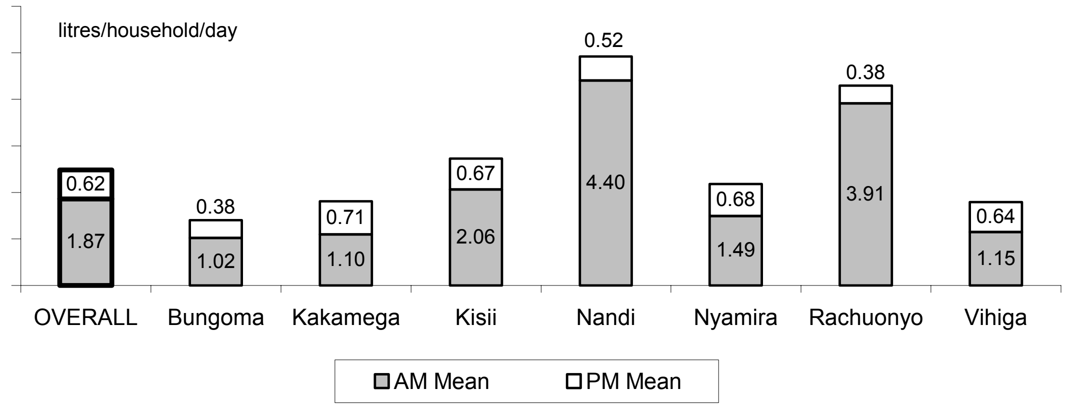
4.11.2 Milk marketing

Three hundred and thirty-five households (33% of households with cattle) indicated that they sold some of the milk they produced (Figure 4.52). The proportion was highest in Vihiga (42%), Nandi (38%) and Kisii (38%) and lowest in Rachuonyo (12%).

The average number of litres sold per household was 1.9 in the morning and 0.6 in the evening (Figure 2.1). Nandi sold the highest amounts per household per day (4.9 litres) while Bungoma sold the least (1.4 litres). Nandi sold the highest amounts both in the mornings (4.4 litres per household) while each of Kisii and Nyamira sold the highest in the evenings (0.7 litres per household).

Individual consumers bought the largest amount of milk at both times of the day (57% of the morning milk and 85% of the evening milk) (Table 4.22). Some of the morning milk was bought by private traders (17%), hotels and restaurants (15%) and retails shops and kiosks (7%). Private traders bought only 7% of the evening milk, while hotels and retail shops took minimal amounts (4%) each. To capture instances where households have difficulties selling milk while others seek certain buyers, amounts given to calves, periodic sales of sour milk and differences between rural and urban consumption patterns can only be done in a consumption study.

Figure 4.52 Average milk sold per household per day



In Nandi the picture was different from the whole area: private traders bought 63% of the morning milk and 41% of the evening milk. The second most important buyers of morning milk in Bungoma and Kisii were hotels/restaurants who purchased 20% and 44% of the milk sold, respectively. In Vihiga it was the retail shops/kiosks who bought 24% of the morning milk. In Nandi and Nyamira private traders bought 41% and 17% of the evening milk and in Vihiga 13% went to retail shops.

Table 4.22 Percentage of morning and evening milk buyers and consumers

		Overall	Bungoma	Kakamega	Kisii	Nandi	Nyamira	Rachuonyo	Vihiga
Morning milk	Individuals	73.2	83.3	86.4	63.0	36.7	93.1	90.0	79.3
	Hotels/Restaurants	8.5	16.7	0.0	28.3	3.3	3.4	0	0
	Private traders	9.9	0	4.5	2.2	53.3	3.4	0	3.4
	Parastatal collection	0.5	0	0	0	3.3	0	0	0
	Coop collection point	0.5	0	0	0	3.3	0	0	0
	Retails shops/Kiosks	6.6	0	9.1	4.3	0	0	0	17.2
	Institutes	0.9	0	0	2.2	0	0	10.0	0.0
Evening milk	Individuals	91.0	100.0	100.0	96.2	77.8	78.9	100.0	90.2
	Private traders	3.3	0	0	0	11.1	15.8	0	0
	Retail shops	2.5	0	0	0	0	0	0	7.3
	Hotels	2.5	0	0	0	11.1	0	0	2.4
	Other	0.8	0	0	0	0	5.3	0	0

Parastatal and cooperative collection points have only been mentioned by 3% (each) of the households in Nandi. Individuals offered the highest prices per litre (KSh 22.15) of milk bought on the farm (farm-gate price) followed by retails shops/kiosks (KSh 21.65) and hotels/restaurants (KSh 20.15) (Table 4.23). Vihiga sold milk at highest prices: KSh 26.70 to hotels/restaurants and private traders. Milk was sold at lowest prices to cooperatives (KSh 14.00) and parastatal collection points (KSh 16.00).

Table 4.23 Farm gate prices offered by different milk buyers per litre

	Overall	Bungoma	Kakamega	Kisii	Nandi	Nyamira	Rachuonyo	Vihiga
Individual customer/consumer	22.15	23.14	25.48	20.87	17.36	19.56	16.93	24.43
Retail shop	21.65		19.33	20.67				22.15
Private milk trader	17.25		16.00	20.00	15.49	19.67		26.67
Institutions (schools/hospitals)	19.33			20.00			18.67	
Hotel/restaurant/office	20.15	25.33		19.44	16.83	14.67		26.67
Parastatal collection point	16.00				16.00			
Cooperative collection point	14.00				14.00			
Other	30.00					30.00		

4.11.3 Milk processing

Beside the milk sold to processors, a half of households with cattle (50%) indicated that they made and sold sour milk (Table 4.24 and Table 4.25). The proportion was highest in Nyamira (77%) and least in Kakamega (15%). Nandi households sold the biggest amounts (6.7 litres on average per day). More of the households practising dairy (51 to 64%) made and sold sour milk than those that do not (35%) (Table 4.24). Sour milk was sold for KSh 25 to 30 per litre, the highest prices being recorded in Nandi, Nyamira and Vihiga.

Table 4.24 Households making and selling sour milk

	Overall	Bungoma	Kakamega	Kisii	Nandi	Nyamira	Rachuonyo	Vihiga
Households with cows	1,020	82	138	191	103	163	103	236
Percent making sour milk	50	22	15	61	58	77	30	58
Percent selling sour milk	48	22	14	59	57	75	29	55
Litres sold per day	2.9			2.0	6.7	4.8	1.2	0.8
Selling price (KSh/litre)	27.63			25.01	29.19	30.30	25.08	29.75

Table 4.25 Households making and selling sour milk

	Zebu only	Zebu +Dairy	Dairy only
Number of households with cows	439	438	134
Percent making sour milk	35	64	51
Percent selling sour milk	33	63	49

5 PRINCIPLE CLUSTER ANALYSIS

5.1 Methodology

Adoption of dairy technologies such as use of specific feeds or feeding strategies, husbandry practices, or breeds of animals, is dependent on household resource constraints, as well as the market and policy environment that the household faces. Thus research aimed at developing appropriate interventions to assist smallholder dairy producers requires a clear understanding of the dairy systems of the target farmers. This is particularly important where 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 primary variables. This method is based on Gockowski and Baker (1996), and uses principal component analysis followed by cluster analysis. The methodology has been tested, during the Kiambu pilot survey and other eight districts surveys (Staal et al 2001).

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 in 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 important variables that explain farming patterns. 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 household observations. Carter (1997) applied a similar methodology to spatial rather than household data.

The process thus consists of two steps:

1. Principal component analysis of several sets of original household variables to identify, within the vector space formed by those variables, new vectors along which most of the variation is observed to occur
2. Households are then scored along the new vectors, and the newly 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 household variables $\mathbf{X} = (X_1, X_2, ..., X_n)$ with positive definite covariance matrix $var(\mathbf{X}) = \mathbf{S}$, 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 $\mathbf{a}=(a1,a2,..,a_n)$

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 subsequent components. (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 covariance. 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, is rotated, to yield more meaningful patterns without altering the statistical explanatory power of the factors. Even with orthogonal rotation, 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 first principal component scores multiplied by original variable values, for example, so that the new variable has variance of one and mean of zero (SAS, 1987).

5.3 Selection of variables used in principal component analysis

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

a. Livestock management of the dairy system,
b. Management of the land
c. Cropping system
d. Level of access to input and output markets, and services.

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

5.4.1 Principal component analysis by level of intensification

Measures of the level of intensification of the dairy system were considered to be centred on 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 tropical livestock unit (TLU). Land available can be considered a measure of availability of gathered fodder and pasture. Measures of purchased feeds are the amount of fodder and concentrate purchased per unit cattle. The measures of intensification were milk produced per acre and percentage grade cattle (local, upgrade and grade cattle). 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 was reduced to 711 for which data were complete.

Table 5.1 Means and standard deviations of variables for level of dairy intensification

Name	Description	Mean (n=711)	Std dev
Maiz_cat	Acreage of maize planted per TLU of dairy cattle	0.62	0.68
Nap_cat	Acreage of Napier acreage planted per TLU of dairy cattle.	0.16	0.27
Conc_cat	Concentrate feed purchased, in KSh, per TLU of dairy cattle	964	2.317
Fodd_cat	Fodder purchased, in KSh, per TLU of dairy cattle	1,003	3,357
Land_cat	Total household land in acres per TLU of livestock	2.29	2.33
Milk-acr	Milk produced per acre	0.56	2.26
Pctgrade	Percentage grade cattle	0.50	0.47
PPE	Precipitation	1.07	0.16

Principal component analysis was carried out on this set of eight variables, using data from the 711 dairy households. Table 5.2 shows the resulting eight principal components, with associated eigen-values and contributions to variation in the eight variables. Gockowski and Doyle (1996) suggest that a common rule of thumb for selecting significant principal components is to consider those with eigen-values 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 three principal components were selected, and then rotated orthogonally to improve interpretability.

Table 5.2 Principal components associated with level of intensification

Priniple component (#)	Eigenvalue (λ_i)	Total variation (%)	Cumulative variation (%)
1	1.8695	23.4	23.4
2	1.4966	18.7	42.1
3	1.0335	12.9	55.0
4	0.9295	11.6	66.6
5	0.8144	10.2	76.8
6	0.7921	9.9	86.7
7	0.7034	8.8	95.5
8	0.3610	4.5	100

The first principal component exhibits the largest eigen value, and alone explains 23% of the variation. The first three principal components (or factors) together explain more than half 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 a zero mean and unit variance, a correlation coefficient or weighting of one indicates strong positive correlation, zero is neutral and negative one shows strong negative correlation.

Table 5.3 Rotated factor pattern for level of dairy intensification

Variable	Factor 1	Factor 2
	Ownfodd	Intense
Maiz_cat	0.8306	0.0193
Nap_cat	0.3504	0.5676
Conc_cat	0.1344	0.6380
Fodd_cat	-0.1075	0.29868
Land_cat	0.8865	0.0711
Milk_acr	-0.3228	0.5055
Pctgrade	0.0602	0.6382
PPE	-0.1320	0.3316

The first factor weighted according to the land held by the household, acreage of maize and planted Napier. This factor thus defines a new variable, which we call 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 second factor represents purchases of concentrates, percentage of cattle exotic genes use of own fodder and milk produced per unit of the land. This indicates an intensified specialised system with optimal resources, which we call INTENSE.

The third factor is essentially neutral with respect to all variables except purchase of fodder and precipitation, with which it is almost perfectly oppositely correlated. This new variable, SUBSIST, thus represents low output low inputs situation, and was dropped in subsequent analyses.

5.4.2 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 household in general. The variables selected as important measures were female-headed, off-farm employment by household members, the overall household income level, the total land held by the household and the ratio of dependants (children under 15 and adults over 65 years) to adults in the household (Table 5.4).

Female-headed households were postulated to have poorer access to resources such as formal credit facilities. Off-farm employment of household members influences availability of important inputs to dairying. Monthly cash income level and total land held were considered indicators of wealth. Dependants' ratio is correlated to household income earning capacity and availability of household labour.

Table 5.4 Means and standard deviations of variables for level of household resources

Name	Description	Mean (n=1018)	Std dev
Femhead	Household is female-headed, 1=no, 0=yes	0.82	0.38
Off_adt	Proportion of household adults (>16 years) working off-farm	0.042	0.095
Income	Total household cash income: 1 =< KSh. 2,500, 2 = 2,500 - 5,000, 3 = 5,001 - 10,000, 4 = 10,001 - 20,000, 5 = 20,001 - 30,000 and 6 > 30,000	2.15	1.22
Totland	Total acres of land held by household	3.81	5.24
Depen_rt	Ratio of dependants to adults	0.45	0.23

Table 5.5 Principal components associated with level of household resources

Principle component number	Eigenvalue	Total variation (%)	Cumulative variation (%)
1	1.4653	29.3	29.3
2	1.0965	21.9	51.2
3	0.9631	19.3	70.5
4	0.7705	15.4	85.9
5	0.7046	14.1	100

The results of the principal component analysis are shown in Table 5.5. Complete data were available from 1018 dairy households. The analysis in this case yields two factors with an eigen-values over one, which together explain 51% of the variation in the selected variables. These factors were thus retained and the correlation coefficients with the original variables are shown below (Table 5.6).

The first factor is weighted significantly negative to the dependants ratio and proportion of household adults working off-farm. The association of off-farm employment and income has been shown in previous studies to be important to dairy intensification (Kaguongo, 1996) and in this case the first factor is significantly correlated to, less to income. It indicates association of number of able-bodied adults in a household either working on or off-farm and dependency ratio and is called OFF-FARM.

Table 5.6 Rotated factor pattern for level of household resources

Variable	Factor 1	Factor 2
	Off-farm	Resources
Femhead	-0.1613	0.5751
Off_adt	0.7449	0.1066
Income	0.2423	0.7018
Totland	0.0211	0.6826
Depen_rt	-0.7880	-0.0155

The second factor identified by the principal components is seen to be strongly correlated with both income and total land holdings. This factor was thus identified as being an index of wealth of the farm/household, and so was given the name resources.

5.4.3 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 2 types of roads (best and worse) to nearest town, the availability of veterinary services (offered mainly by the government and NGO sector), GoK extension services, the farm-gate price of milk received by the farmers, co-operative membership, and milk sales to informal market outlets. The variables are described in Table 5.7. The study shows that government veterinary and extension services were still significant to over ninety percent of the farmers. Complete data was available from 219 dairy farm/households.

The results of the principal component analysis for market access, shown in Table 5.8 reveal one significant factor that alone explains 20% of the variation in the seven selected variables; it has a large eigen value of 1.42. There were three factors which had an eigen value greater than one. The factor loadings against the original variables are shown in Table 5.9

The first factor has strong correlation with all weather road type and participation in the co-operative output market but neutral to other variables. This variable we shall call Mktacc. The coefficients of the second factor show strong correlation with bad road type but a strong negative correlation with farm-gate milk price (Table 5.9). The new variable defined by this factor was given the name Nomktacc. The negative correlation to farm-gate milk price has in this case been shown to be lower with bad roads. The third factor had a strong correlation with veterinary and extension services, which had been shown to be over ninety-five percent present, and this factor was dropped in subsequent analyses.

Table 5.7 Means and standard deviations of variables for market access

Name	Description	Mean	Std dev
Rdtype1	Distance to nearest town for road type 1 in KM	21.39	20.07
Rdtype3	Distance to nearest town for road type 3 in KM	2.49	3.18
Vetavail	Availability of veterinary services (1=yes, 0=no)	0.95	0.23
Extavail	Availability of extension services (1=yes, 0=no)	0.94	0.24
Pricelt	Average price received per litre of milk in most recent dry season	21.29	5.49
Coopmemb	Co-operative membership: 1=yes, 0=no.	0.037	0.189
Infrmkt	Milk sales to non-co-operative outlet in last 12 months, 1=yes, 0=no	0.99	0.11

Table 5.8 Principal components associated with market access

Principle component number	Eigenvalue	Total variation (%)	Cumulative variation (%)
1	1.4196	20.9	20.3
2	1.2102	17.3	37.6
3	1.1074	15.8	53.4
4	0.9531	13.6	67.0
5	0.8908	12.7	79.7
6	0.8109	11.6	91.3
7	0.6081	8.7	100

Table 5.9 Factor pattern for level of market access

Variable	Factor 1 Mktacc	Factor 2 Nomktacc
Rdtype1	0.7453	-0.0450
Rdtype3	-0.1441	0.8356
Vetavail	0.1275	0.1102
Extservice	-0.1644	-0.0834
PriceIt	-0.2288	-0.7311
Coopmemb	0.6009	-0.0174
Infirmkt	-0.5470	-0.1486

5.5 Cluster analysis

5.5.1 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. Table 5.10shows the frequency of households falling under the different clusters, and the mean values of the newly defined variables.

Table 5.10 Frequency of households by cluster, variable means for dairy intensification, household resources and accessibility to services

	Freq	Extlanded	Intense	Offfarm	Wealth	Mktacc	Nomktacc
1	164	-0.1460	-0.3538	-1.1568	-0.1244	0.0632	1.0983
2	226	-0.4750	0.4630	-0.1468	0.6750	-0.4066	0.3003
3	269	-0.1285	-0.6452	0.1715	0.5264	-0.1675	-0.7323
4	50	-3.2781	6.8333	-0.7332	-1.3124	0.0813	-0.8924
5	111	-0.0928	0.4516	0.1794	-1.7401	-0.2894	-0.4885
6	57	0.2613	2.0996	0.6568	-0.1568	4.7122	1.2319
7	83	2.5696	0.2541	0.2097	0.0611	1.4147	-0.5284
8	60	0.2317	-0.0296	2.3117	-0.2027	0.4427	0.6936

5.5.2 Cluster groupings

The cluster results show four clusters containing most of the farm/household observations with cluster 1 containing the largest 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 (cluster 3) had the least intensification, a higher percent of adults working off-farm and had the second lowest market access and second highest wealth level. We shall call this group of dairy farmers resource endowed poor access (REPA). The second largest is cluster 2, the intensive specialized dairy farmers (ISD) who are most intensified and wealthy but had a lower market access with insignificant number of adults working off-farm.

Cluster 1 farmers exhibit an extensive farming, therefore low levels of purchased fodder, low levels of wealth and poor market accessibility and are therefore the resource poor dairy farmers (RPOOR). Cluster 5 potentially represents the dairy producers, who are intensive with a significant number of adults working off-farm, less wealth and low market access. This last group can therefore be called intensive part-time (SPF) producers. These general characterisations will be further detailed by examination of more of the original variables underlying the clustering.

5.5.3 Cluster means of original variables

Table 5.11 shows mean values by cluster for a number of variables obtained from the farm/household survey. They generally emphasise the distinctions between the clusters. The resource poor group can be seen to be a third of the overall clustered sample and are distinguished by having average land sizes, among the smallest acreage of Napier planted, lowest purchase of fodder and concentrates and below average incomes. Table 5.11 shows mean values by cluster for a number of variables obtained from the farm/household survey. They generally emphasise the distinctions between the clusters.

The Resource poor groups- REPA and RPOOR constitutes over 50 percent of the target clustered sample and are distinguished by having the lowest average acreage of Napier and maize planted, among the lowest purchases of fodder and concentrates and generally low grade cattle and lower milk yields. However the REPA group are more disadvantaged as compared to RPOOR by having less land sizes, lower dairy cattle per TLU, lower incomes and poor market access which resulted in less milk sales.

The intensive group of farmers-ISD and IPT on average purchase more fodder and concentrates and produce more milk. They also have more multiple market outlets which enable them to negotiate for higher milk prices and hence able to market more of their milk. The major distinction between the two groups of intensive farmers is that IPT is more female headed and this seems to be so because more adults work off-farm and also seem to allocate more land per TLU than the ISD

Table 5.11 Means of farm/production, household and market/institutional participation characteristics for the major target groups

cluster	resource endowed poor access	intensive specialised	resource poor	intensive part-time
Number of Households	164	226	269	111
Production characteristics				
Farm size (acres)	2.1	2.2	3.2	3.6
Napier acreage	0.1	0.2	0.1	0.5
Maize acreage	0.6	0.6	0.9	0.9
Dairy cattle TLU	1.4	1.8	2.1	2.1
Farm acres per TLU	1.8	1.5	1.9	2.1
Napier acres per TLU	0.1	0.2	0.1	0.3
Maize acres per TLU	0.5	0.4	0.6	0.5
Concentrate purchased KSh/TLU/year	370.5	1026.0	292.2	1609.1
Fodder purchased KSh/TLU/year	443.1	1192.6	422.8	1618.7
Milk produced (litres/day)	0.7	1.7	0.6	1.9
Milk produced per day (litres/acre)	0.4	0.9	0.3	0.9
Percentage grade	0.4	0.7	0.3	0.7
Household characteristics				
Age of household head	49.3	48.4	50.7	51.8
Years farm established	26.8	21.7	23.7	26.0
Years dairy experience	25.3	20.0	22.5	23.0
Female heads (%)	31.7	92.0	98.1	83.8
Total household size	5.3	6.4	6.7	6.3
Household adults working off-farm (%)	2.2	0.6	1.1	19.2
Income category	1.3	1.8	2.1	3.0
Dependency ratio	41.5	58.4	54.4	19.2
Market /institutional participation characteristics				
Distance road type 1 (km)	18.9	18.1	21.2	16.3
Distance road type 3 (km)	3.3	2.7	1.9	1.8
Co-op membership (%)	2.4	2.2	1.9	3.6
Availability of veterinary services (%)	93.9	92.3	96.6	99.1
Availability of extension (%)	91.5	96.0	95.2	99.1
Informal milk market participation (%)	100.0	100.0	100.0	100.0
Multiple market outlets (%)	3.8	10.9	5.9	5.4
Average milk price (KSh/l)	17.1	19.5	24.9	24.3
Average milk sold (litres/day)	1.7	3.5	2.2	4.1

6 Conclusions

Most households were agricultural and of those more than two thirds had cattle. Zebu cattle took more than forty percent of the households with cattle while grades were only 13 percent and this distribution did not change between households with cattle and those without. As was indicated in the PRAs, there were very few small ruminants (sheep and goats) and their contribution in providing milk and manure to different systems was minimal. There was high preference for Zebu cattle contrary to the fact that the agro climatic potential is extremely favourable for grade cattle production and the demand for milk is quite high in the region. Although tethering as the main system of keeping cattle is on the decline due to increasing pressure on land, stall-feeding is not very common while the cattle appear to be under fed. Thus many opportunities exist for promoting livestock productivity through improved nutrition.

The growing importance of dairying was further indicated by the prevalence of milking cows and heifers in the herds. The main system of keeping cattle was grazing with some stall-feeding but very little zero grazing was practiced. Grazing was mainly associated with the Zebu while stall-feeding was associated with crosses and grade animals. Cut and carry was common across all animal types whether Zebu or grade. Only less than 16% of the households supplemented their cows with concentrates. About a fifth of the households purchased fodder and stored forage for the dry season. The majority of the farmers used maize as a fodder crop by removing thinnings to reduce the density. A third of the farmers used the extra plants to feed livestock. The majority of farmers indicated that they purchased fertilizers and applied manure but there was no sale or purchase of manure except in Rachuonyo.

Most farms were free hold although there were pockets with traditional land ownership and little incidences of leasing land. Most of this land was used for food crops followed by pasture, cash crops and little fodder crops. In many instances the food crops were also cash crops as they were a major source of income. There was however, more Napier grown on contours than as a fodder on its own. This allocation did not change whether the farm had cattle or not. The only exception again was Nandi which had more pasture than even the food crops. This implies that most farming is subsistent and commercial farming is also common and there is scope for improving animal productivity through more integration of cattle in the farming systems and growing of more fodder crops.

Major changes that have occurred in terms of crops not grown in the last ten years but grown now were: Napier grass, fruit trees, tea and bananas. Those that were grown ten years ago but were no longer grown were cassava, sorghum, millets and sweet potato. This indicated the growing importance of cattle and early stages of intensification.

Non-agricultural households tended to have fewer household members because they were urban. The majority of household heads were men who also happened to own the land. However most adult women took care of cattle in grazing, cutting and carrying fodder. 60% of household females also took charge of selling milk and milking but the male household heads specialised in animal health related tasks such as artificial insemination, spraying and seeking treatment.

There was generally low engagement of long-term labour though there was slight employment of casuals. These were employed to help in planting and weeding of food crops. This further supports subsistence orientation of production.

Most households had little income and only those with cattle especially dairy enjoyed much higher incomes. Milk output was quite low at an average of 2.7 litres per cow per day with the grades reaching only 5.1 litres per day. Most of this milk was consumed at home as there were little sales to individuals.

The prevalence of public utilities such as piped water, electricity and telephone were less than 5%. The shortest roads to the nearest market centres are only accessible in the dry season. The main mode of transport was the bicycle and animal drawn carts.

Credit use was very low as many had never thought of such services or were afraid that they would be unable to repay once they got it. Availability of public extension service was very high though some from NGOs and private agents also existed. However, there was only one visits per year.

The worst diseases were helminthiasis, ECF and anaplasmosis. Presence of veterinary service was high but paravets were also common.

7 References

Carter, S.E. 1997 Spatial Stratification of Western Kenya as a Basis for Research on Soil Fertility Management. Agricultural Systems, 55 (1), 45-70.

Gockowski, J.J. and Baker, D. 1996. Targeting Resource and Crop Management Research Through an Eco-regional Methodology for the Humid Forest of Central and West Africa. Paper presented at 1996 Biennial Meeting of Rockefeller Social Science Research Fellows, Aug. 15, 1996, Nairobi, Kenya

Jabbar, M.A., Tambi, E. and Mullins, G. 1997. A methodology for characterizing dairy marketing systems. Market-oriented smallholder dairying research Working Document No. 3., ILRI-Nairobi. 62p

Kaguongo, W.N.W. 1996. Smallholder adoption of dairy technologies: effect of risk management strategies in a liberalising economy. Msc. Thesis, University of Nairobi.

Lessard, P., L'Eplattenier, R., Norval, R.A.I., Kundert, K., Dolan, T.T., Croze, H., Walker, J.B., Irvin, A.D. and Perry, B.D. 1990. Geographical information systems for studying the epidemiology of cattle diseases caused by Theileria parva In Veterinary record (1990) 126, 255-262

Mullins, G., Rey, B., Nokoe, S. and Shapiro, B. 1994. A research methodology for characterising dairy product consumption systems. Smallholder Market-oriented Dairy Research Working Document No.2. ILCA: Addis Ababa, Ethiopia

Rey, B., Mullins, G., Agyemang, K., Shapiro, B., Nokoe, S., and Thorpe, W. 1998. A research methodology for characterising dairy production systems. Market–Oriented Smallholder Dairy Research ILRI, Nairobi.

Rey, B., Thorpe, W., Smith, J., Osuji., P., Mullins, G., Agyemang, K. 1993. Improvement of dairy production to satisfy the growing consumer demand in sub-Saharan Africa. A conceptual framework for research: Market–Oriented Smallholder Dairy Research Working Document No. 1. ILCA 13pp.

SAS Institute 1999. SAS/STAT Software, Release 8.00, Cary, NC: Author.

Staal, S.J., M. Owango, H. Muriuki, B. Lukuyu, F. Musembi, O. Bwana, K. Muriuki, G. Gichungu, A. Omore, M. Kenyanjui, D. Njubi, I. Baltenweck, L. Njoroge and W. Thorpe. 1998. Dairy Systems Characterisation of the Nairobi Milk Shed

Waithaka, M., Wokabi, A., Nyangaga, J., Ouma, E., Biwott, J., Staal, S., Ojowi, M., Ogidi, R., Njarro, I., and Mudavadi, P. 2000. A participatory rapid appraisal (PRA) of farming systems in western Kenya. Report of a PRA on dairy and crop activities in western Kenya January 24th to February 5th, 2000. MoA/KARI/ILRI Smallholder Dairy (Research & Development) Project Report, Ministry of Agriculture (Kenya), Kenya Agricultural Research Institute and the International Livestock Research Institute (Kenya). Nairobi, Kenya.

Annex 1 Selection of sub-locations

Table A1.1 Western divisions grouped by dairy related characteristics

Access	PPE		
	Low (0.7-0.85)	Medium (0.85-1)	High (>1)
Kakamega			
Medium (1-2 hrs.)		Malava/Kabras (46)	
High (< 1hr.)		Butere (91), Lurambi (61), Mumias (103)	Ikolomani (120), Kwisero (108), Shinyalu (157)
Bungoma			
Low (> 2 hrs.)		Kapsokwony (59) Kimili (121)	
Medium (1-2 hrs.)	Tongareni (35)	Kanduyi (72), Sirisia (52), Webuye (57)	Nalondo (75)
Nandi			
Low (> 2 hrs.)			
Medium (1-2 hrs.)			Mosop (22), Aldai (32), Kapsabet (41), Kilibwoni (32), Tindiret (45)
Vihiga			
High (< 1hr.)			Emuhaya (188), Hamisis (119), Sabatia (180), Vihiga (164)
Nyamira			
High (< 1hr.)			Borabu (30), Ekerenyo (207), Magombo (96) Nyamira (98)
Rachuonyo			
Medium (1-2 hrs.)		Oyugis (61)	
High (< 1hr.)	Kendu Bay (61)		
Kisii			
Medium (1-2 hrs.)		Bosongo (85), Suneka (105)	Marani (109), Nyamache (91), Ogembo (99)
High (< 1hr.)		Kisii Municipality. (132)	Irianyi (96), Masaba (89)