MoA/KARI/ILRI Collaborative Research Project Report

Intensification of Dairying in the Greater Nairobi Milk-Shed: Spatial and Household Analysis

I. Baltenweck[3], S. J. Staal[3], M. Owango[1], H. Muriuki[2], B. Lukuyu[1], G. Gichungu[2], M. Kenyanjui[3], D. Njubi[3], J. Tanner[3] and W. Thorpe[3]

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[1]Kenya Agricultural Research Institute
PO Box 57811
Nairobi, Kenya

[3]International Livestock Research Institute
PO Box 30709
Nairobi, Kenya

[2]Ministry of Agriculture, Livestock Development and Marketing, Livestock Production Department
PO Box 728, Kiambu

Résumé

Les systèmes de production laitière au Kenya varient beaucoup et diffèrent en termes de race, d'intensité d'utilisation des intrants terre et travail et des systèmes d'alimentation du bétail. La libéralisation du secteur laitier de 1992 a encouragé la production de lait en permettant aux coopératives laitières et à des entrepreneurs privés de jouer un rôle plus important dans la commercialisation des produits laitiers. Des changements dans les systèmes de production et de commercialisation sont donc apparents mais n'ont pas été documentés jusqu'à présent. Une étude menée conjointement par KARI (Kenyan Agricultural Research Institute), Ministry of Agriculture et l'ILRI (International Livestock Research Institute) a pour objectif de characteriser les systèmes de production laitiers dans le bassin de collecte de Nairobi afin d'identifier les contraintes et opportunités d'un développement futur. Une enquête a été menée aux mois de mars et avril 1998 sur un échantillon aléatoire de 1389 ménages dans huit districts du Kenya. Cette première caractérisation met en évidence la forte variabilité des stratégies de production présentes dans les zones couvertes par l'enquête ainsi que la compétitivité croissante des systèmes de production moins intensifs. Une autre particularité de l'étude est l'utilisation conjointe du système d'analyse géographique (Geographical Information System) et au niveau de la ferme. Ainsi des cartes représentant des indicateurs d'intensification laitière permettent de visualiser la répartition géographique des différents systèmes. Un indicateur synthétique a également été construit, la quantité de lait produit par unité de terre; cet indicateur est ensuite comparé à des indicateurs du niveau de compétitivité au niveau de l'exploitation, les cash flows nets et les rendements du travail. Les données montrent que la relation entre intensification et compétitivité n'est pas simple puisque au niveau de la ferme et par nombre de vache, les systèmes les plus intensifs ont les niveaux les plus élevés de cash flows et de rendements du travail, alors que par quantité de lait produit, ce sont les systèmes les moins intensifs qui apparaissent les plus compétitifs.

Introduction

Smallholder dairy farmers produce some 56% of total milk production in Kenya and 80% of the total marketed milk (Peeler and Omore, 1997). Milk production systems vary widely, however, differing in the breeds of animals used, intensity of land and labour use, and feeding systems. The 1992 milk market liberalisation gave impetus for the increased offtake of milk, by improving opportunities for dairy co-operatives and private entrepreneurs to market dairy products. As a result, changes are apparent in production and marketing in the greater Nairobi milkshed. Yet little is known about these patterns of change and the effects of various determinants on them. A collaborative study by KARI/MoA/ILRI was undertaken to conduct the first systematic characterisation of the Nairobi milkshed, with a view to identifying constraints and opportunities for further development.

The characterisation of livestock production systems typically focuses on specific representative locations, thus compromising the validity of extrapolating the results, or it takes a broad view, thus compromising the detail of the results. By surveying randomly-selected households within areas stratified by land use zones, and by applying a combination of GIS-based spatial analysis techniques and statistical methods, this study provided detailed system and farm-level analysis across a wide range of farm and livestock sub-systems within the Nairobi milk-shed. The collaborative KARI/MoA/ILRI team gathered data in March-April 1998 from 1389 households in eight districts that represent a wide range of levels of dairy productivity potential and market access within the Nairobi milk-shed. This first systematic characterisation describes the wide variability of production strategies present in a relatively small area, and the growing competitiveness of less-intensive dairy production. It also applies in the Kenya setting some of the new methods available through linking GIS-based and farm-based analysis. Data show the importance of direct milk sales to the final consumers and the role of small informal milk traders, in spite of the relative state of development of the Kenyan formal dairy industry.

Survey design and implementation

A diagnostic survey to characterise the smallholder dairy households was conducted in Central, Eastern and Rift valley provinces of Kenya (KARI/MoA/ILRI 1998). This was done to compliment the earlier one done in Kiambu District. Prospective study sites were grouped according to production potential and market access into High-High, High-Medium, High-Low, Medium-High, Medium-Medium and Medium-Low as shown below:

Agro-ecological potential	**Level of market access**	**District(s)**
High potential	High market access	Kiambu
	Medium market access	Kirinyaga, Murang'a
	Low market access	Nyandarua (south)
Medium potential	High market access	Nairobi and Machakos
	Med. Market access	Nakuru
	Low market access	North Narok

The districts chosen to carry out the survey in 1998 were Narok, Nairobi, Maragua, Murang'a, Nakuru, Nyandarua, Kirinyaga and Machakos.

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

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

Survey maps for each of the 82 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 sublocations and marked on the map the main landmarks (any permanent feature like a trading centre, a school, or a church). Two (or three) pairs of landmarks were then selected at random for each sublocation and line transects were drawn joining each pair. Sampling was thereafter done following as closely as possible the marked transects. Every 5^{th} household on the left and on the right was interviewed alternately, regardless of whether they were agricultural or kept dairy animals. In this way, a random sample of all sublocation households was obtained.

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

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

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

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

and checked for data entry errors. Descriptive statistical analyses were carried out using Stata software.

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

Intensification level in dairy farming: indicators and relationship to land size

The results showed that a majority of rural households are agricultural (74.8% of the surveyed households) and many practice dairy farming (75.3% of the agricultural households). There is an increasing shift towards intensification of dairying through growing of fodder crops with "cut-and-carry" feeding systems and keeping of improved dairy breeds on the ever decreasing land available for agriculture.

The results presented here include data from the eight districts described in section 2 and from Kiambu district, where the pilot survey was carried out in 1996. The questionnaire has been slightly modified and some variables are not identical. When interpreting the results, it is worth keeping in mind that the Kiambu results reflect the situation two years before the other districts. Nevertheless data on prices have been updated and are these of 1998[2].

Analysing the data at the district level reveals the high variability of the existing production systems and the level of milk production. Annex 2 presents the average milk production per household per division. The variable is defined as the average milk production at the time of the survey per household per district. It can be seen that the production varies between divisions, from 3.13 litres in Kangundo (Machakos district) to 22.44 litres in Kasarani (Nairobi district) and between households as the high standard deviations show. One indicator of the level of intensification is the level of milk production per household per unit of land and the variable is presented in table 2 and map 2. Four classes of intensification level per division were constructed so as to group approximately one fourth of the households in each class: low level of intensification if the average production per household per unit of land in the division is less than 500 litres per year; intermediate low when the variable is between 500 and 700 litres; intermediate high when the variable is between 700 and 1000 litres; and high level for values above 1000 litres. The map shows the heterogeneity in the intensification level by distinguishing the highly intensified areas that are mainly situated next to Nairobi from the less intensified ones like Narok in Masaailand and Machakos. It is worth noticing that Njoro and Bahati exhibit a high density of milk production as well. These two areas are located in Nakuru district and it can be seen that land size in these two areas are among the smallest (see map on land size). The relationship between the level of intensification and land sizes will be analysed more deeply at the end of this section.

Other indicators of the intensification level reveal these geographical patterns. These are the dominant system for keeping cattle in the division, the dominant main breed,

[2] Data on prices are collected on a weekly basis for the on-going longitudinal survey covering 21 farmers in Githunguri, Kiambaa, Kikuyu and Limuru divisions. Price data are missing for Lari division because this area had not been selected for that survey.

the percentage of cropped land, the percentage of households hiring labour for dairy activities, the percentage of cost of purchased feed in total feeding cost and finally the percentage of cash from sale of animals in total dairy income. Statistical indicators for these variables are presented in annex 2.

The dominant system for keeping cattle is defined as the dominant current system in the division. The question asked to the farmers included a fourth category, " mainly stall feeding with some grazing", but this category was not predominant in any of the surveyed division. The main system in the surveyed divisions is "only stall feeding" (12 over the 20 division), then "grazing" and finally "mainly grazing with some stall feeding" or semi-zero grazing. The semi-zero grazing described is paddock grazing on improved pastures with a little "cut-and-carry" as in the High-Low site (Nyandarua) or enclosing of animals in semi-permanent structures with predominantly "cut-and-carry" with a little grazing as in the High-Med.area. Areas where stall feeding is dominant are the ones close to Nairobi (southern divisions of Kiambu and Kasarani), Bahati division and Murang'a, Maragua and Kirinyaga districts.

As for the dominant breed, it differs a lot between divisions, in a way similar to the system for keeping cattle. In fact, improved animals are more present where the main system is stall feeding while local animals are found in grazing areas. The mean number of zebu, cross and grade cattle per household is 6.9 (SD 9.6), 3.8 (SD 4.30 and 3.5 (SD 5.0) respectively with the predominant dairy breeds reportedly being Friesian (42%), Ayrshire (18%), Guernsey (12%) and Jersey (3%) with the *Bos indicus* (SEAZ, Sahiwal and boran) reported in 25% of farms.

Cropped land is defined as the total land size minus pasture and fallow. Note that data from Kiambu district do not show any pasture, thus the percentage of cropped land on farms, including that planted in fodder, is 100%. We cannot rule out the possibility that the survey in that district did not capture the pasture acreage with enough accuracy. This variable is difficult to interpret since for Narok division in particular, the percentage is higher than expected. The reason is that farmers graze their animals on communal land, thus the percentage of used land (as opposed to owned land) in pasture and fallow is in reality much higher.

The percentage of households hiring labour for dairy activities reflect those households in the division who hire external labour whose work is "mainly" related to dairy activities. "Mainly" means that they spend more than 50% of their time on dairy activities for all the districts, except for Kiambu where it means that it is the labourer who is primarily responsible for carrying out the dairy activities. A high level can be explained by two very different ways: for high-intensified system, labour is necessary to carry out the feeding activities that are highly time consuming. On the other hand, for less-intensified systems where animals graze, hired labour are used for this activity. It is thus not surprising to see that some of the districts classified as less intensified have a high percentage of households hiring labour for dairy activities.

The next indicator of intensification level is the percentage of purchased feed in total cost of feeding where the total cost is equal to the cost of purchased feed plus the opportunity cost of growing on-farm feed. The opportunity cost of on-farm feeding is the reported rental value of the land planted in Napier, in pasture or left fallow. This way of calculating the total cost has an important influence on the result. For Kasarani for example, we expect household to have less land available to grow on-

farm feed and then the percentage to be high. Since the rental rates are very high, it appears that the percentage is less than 50%.

The percentage of cash from sale of animals in total dairy income is defined as the income from sale of animals in total income from dairy activities, which includes the income from milk sale plus the income from sale of animals. Narok farmers get more than half of their dairy income by selling animals, while for the farmers next to Nairobi in particular, animals sale constitutes less than one sixth of the income from dairy activities.

The size of land holding per household varies greatly, and is generally seen as one of the main determinants of the intensification level. In the districts where land sizes are small and land is thus a primary constraint to production, farmers have an incentive to intensify and the main system of keeping cattle is “stall feeding”. Kiambu and Kasarani are good examples of this pattern. The next table shows that the difference of land sizes is statistically different between type of keeping cattle, with the households with more (less) land adopting a less (more) intensified system.

Table 2: Mean land size per household by system of keeping cattle

System of keeping cattle	Number of households	Mean of land size	Statistical difference at 5%
Grazing (1)	171	12.17	Yes with systems 3 and 4
Mainly grazing (2)	193	10.98	Yes with systems 3 and 4
Stall feeding (3)	262	3.57	Yes with systems 1and 2
Mainly stall feeding (4)	75	4.13	Yes with systems 1 and 2

The main marketing channels are presented in Annex 2. Individuals include individual customers, hotels and restaurants while organised marketing channels include private dairy processors, parastatal collection point, cooperative collection point and farmer group. In 12 of the 20 divisions, the main outlet is individual consumers, hotels and restaurants. In terms of percent of main outlet reported by households, at the household level milk sales are through individuals for 42% of households, traders 22%, dairy co-operative societies and groups 12%, hotels and shops 11% and private processors and Kenya Co-operative Creameries each 6%.

The areas where farmers sell mainly to an organised channel are the northern divisions of Kiambu where co-operatives are well functioning (particularly in Limuru) and Nyandarua, where the Kenya Co-operative creameries, previous to 1992 the sole authorised processor, is still a relatively important buyer as well as some processors and co-operatives. On the other hand, there are only a few divisions where private traders are dominant and these are Molo (Nakuru), Kangema (Murang’a) and Kiambaa (Kiambu). The first two are in areas quite far removed from urban consumption areas, where more organised milk collection doesn’t appear to have reached. As a consequence, although this area is thought of a the milkshed supplying Nairobi, the observed importance of direct sales by producers to local consumers shows that much if not most of the milk remains within this relatively high population production area.

Competitiveness and level of intensification

In order to assess the link between the level of intensification and competitiveness, two indicators were calculated. The first is the net cash flow from dairy activities per

household calculated as the sum of the income from milk sale and from sale of animals minus the cost of hired labour, of feed expenditures, of health services and of purchases of animals. The cost of hired labour is the wage paid to the labourer(s) times the percentage of time spent on dairy activities. For Kiambu district, the cost of hired labour and the cost of health services were not available and as a consequence these two costs could not be included. Net cash flows were calculated by household (average by division), per cow (net cash flows divided by the number of cows) and per ton of milk produced (net cash flows divided by the annual milk production).

The second indicator is the return to family labour from dairy activities: they include the opportunity value of the milk consumed as well as the opportunity cost of the feed produced on-farm. Thus returns to family labour are equal to the income from milk sales, from sale of animals and the market value of the milk consumed minus the cost of hired labour, feed expenditures, cost of health services, cost of purchases of animals and the rental value of land used to supply fodder or pasture. Returns were calculated per farm, per cow and per ton of milk produced in the same way as the net cash flows.

When comparing the maps showing the level of intensification with the ones showing the indicators of competitiveness it appears that the less-intensified districts have relatively high levels of cash flows (see Narok and Machakos) while some areas that are highly intensified (Kiambu divisions) experience rather low levels of cash flows. The following tables show the distribution of cash flows per farm and of profits per farm by level of intensification.

Table 3: Net cash flow per farm, by level of intensification calculated at the household level

Level of Intensification	Number of households	Average net cash flows	Statistical difference at 10%
Low (1)	114	37 337	None
Intermediate low (2)	141	36 239	None
Intermediate high (3)	170	41 454	None
High (4)	183	48 808	None

Table 4: Returns to labour per farm, by level of intensification calculated at the household level

Level of Intensification	Number of households	Average returns	Statistical difference at 5%
Low (1)	108	32 875	(1) < (3) and (1) < (4)
Intermediate low (2)	132	44 629	None
Intermediate high (3)	158	53 741	(3) > (1)
High (4)	174	57 650	(4) > (1)

The cash flow results show a generally clear relationship with level of intensification (Table 3), with cash flow increasing with intensification. None of these differences, however, are statistically significant. Returns to labour per farm, however, are clearly and significantly positively related to level of intensification (Table 4). This shows that, at current levels of prices and values for land, intensive dairying offers the highest returns to a household unit. However, this does not recognise differences in the opportunity cost of family labour between these areas, as those opportunity costs are likely to be considerably higher in high intensity areas.

A more clear indication of level of competitiveness may be available from calculating these results per ton of milk produced (Tables 5 and 6).

Table 5: Net cash flow per ton of milk produced, by level of intensification calculated at the household level

Level of Intensification	Number of households	Average net cash flows per ton of milk produced	Statistical difference at 10%
Low (1)	114	20 562	(1) > (2) and (1) > (4)
Intermediate low (2)	141	14 279	(2) < (1)
Intermediate high (3)	170	15 219	None
High (4)	183	9 679	(4) < (1)

Table 6: Returns to labour per ton of milk produced, by level of intensification calculated at the household level

Level of Intensification	Number of households	Average returns per ton of milk produced	Statistical difference at 10%
Low (1)	108	24 140	(1) > (4)
Intermediate low (2)	132	18 733	(2) > (4)
Intermediate high (3)	158	19 801	(3) > (4)
High (4)	174	12 280	(4)<(1), (4)<(2) and (4) < (3)

The per ton results show that more intensified farms earn on average lower returns to labour than less intensified farms per quantity of milk produced. Although at the farm level and per animal, farmers with intensified rearing systems are better-off, per unit of milk produced less intensified systems are more competitive. These results suggest that if milk prices fall, low intensity systems will remain competitive, while high intensity dairy production may not. Own-farm feeding and use of pasture when land is available may thus be an economical way to produce milk, and high intensity zero-grazing cannot be viewed as the only means to increase milk production in Kenya, in spite of the emphasis on that approach by many dairy development efforts. The use of higher levels of external inputs (labour, feeding, veterinary services and extension services) characteristic of high intensity dairying is not economical in areas where poor market access and lack of organised marketing channels result in low milk prices.

Conclusions

The survey conducted in eight districts in Kenya shows how the production systems are different even in the relatively small area surveyed. They differ in terms of level of intensification, market access and level of competitiveness. More intensified systems are found mainly in the divisions close to Nairobi where high milk prices act as an incentive to produce more as well as in the divisions where land (rather than labour) is a limiting factor due to the population pressure. Nevertheless there is no clear-cut relationship between the intensification level and the level of competitiveness at the farm level. Per farm and per cow, more intensified systems show higher levels of net cash flows and returns to family labour, while per quantity of milk produced less intensive systems appear to be more competitive.

Production systems in dairy farming in Kenya thus display a wide variability of strategies, each of it responding to the particular marketing and environmental conditions present in the area. The longer term competitiveness of these systems, therefore, depends not only on the direction in which labour and land values change over time, but also on changes in market and institutional infrastructure. The results show that organised marketing channels are still mainly predominant in areas closer to the Nairobi milk shed, while in more distant areas, direct sales to consumers and traders prevail. If road and market infrastructure improves over time, organised marketing is likely to better reach distant areas, enabling high milk prices to those producers. Under those circumstances, the competitiveness of production is likely to shift significantly.

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Annexes

Annex 1: Tables

Tables of average milk production per household, main system for keeping cattle now and 10 years ago, land size, percentage of households keeping local or improved animals, percentage of cropped land, percentage of households hiring labour for dairy activities, percentage of purchased feed, percentage of cash from sale of animals in total income, main milk outlet, net cash flows per farm, per cow and per ton of milk produced and returns to labour per farm, per cow and per to of milk produced.

Total milk production per district (data from the MoA):

Districts	Total milk production (Kg)
KIAMBU	132 473 456
NYANDARUA	84 844 310
NAKURU	71 970 729
MACHAKOS	67 173 757
MURANGA	60 661 455
KIRINYAGA	56 561 483
NAROK	46 713 945
NAIROBI	0

Average milk production per household

Division	Average milk production (litres)	Std. Dev.
Kandara	5.74	5.31
Kangema	6.24	7.54
Kiharu	3.43	3.24
Gichugu	4.99	4.80
Ndia	4.76	4.15
Kasarani	22.44	37.22
Kangundo	3.13	3.46
Mwala	4.29	7.38
Kinangop	20.23	24.30
Ol_Kalou	15.42	19.89
Bahati	5.66	4.68
Molo	13.84	17.81
Njoro	13.01	12.95
Rongai	14.45	26.46
Mau	8.27	8.39
Githunguri	7.54	9.95
Kiambaa	6.08	5.57
Kikuyu	4.82	7.35
Lari	5.95	6.16
Limuru	4.77	5.85
Mean	*8.75*	

Current main reported system for keeping cattle: percentage of households in each category

Division	System for keeping cattle			
	only grazing	Mainly grazing	only stall feeding	mainly stall feeding
Kandara	0	0	90	10
Kangema	19	19	49	13
Kiharu	5	10	72	13
Gichugu	12	23	50	15
Ndia	0	12	74	14
Kasarani	0	27	73	0
Kangundo	30	19	38	13
Mwala	59	28	13	0
Kinangop	6	82	4	8
Ol_Kalou	43	40	7	10
Bahati	11	27	43	19
Molo	21	48	19	12
Njoro	30	44	9	17
Rongai	59	35	4	2
Mau	97	3	0	0
Githunguri	10	8	64	18
Kiambaa	11	6	83	0
Kikuyu	7	11	82	0
Lari	49	17	30	4
Limuru	6	13	71	10
Number of divisions where the system is dominant	***5***	***3***	***12***	***0***

Main system for keeping cattle 10 years ago: percentage of households in each category

Division	System for keeping cattle			
	only grazing	Mainly grazing	only stall feeding	mainly stall feeding
Kandara	0	2	91	7
Kangema	39	7	47	7
Kiharu	9	8	72	11
Gichugu	53	6	22	19
Ndia	11	14	58	17
Kasarani	80	0	20	0
Kangundo	36	26	21	17
Mwala	70	30	0	0
Kinangop	6	82	4	8
Ol_Kalou	54	36	5	5
Bahati	22	19	46	13
Molo	44	34	14	8
Njoro	85	3	2	10
Rongai	66	29	5	0
Mau	100	0	0	0
Githunguri	18	15	49	18
Kiambaa	50	7	36	7
Kikuyu	29	18	53	0
Lari	69	16	15	0
Limuru	33	22	33	12
Number of divisions where the system is dominant	***12***	***1***	***7***	***0***

Land size (in acres)

Division	Land size	Std. Dev.
Kandara	3.10	5.64
Kangema	3.40	3.54
Kiharu	2.87	2.99
Gichugu	4.20	3.85
Ndia	3.32	3.01
Kasarani	7.09	20.28
Kangundo	7.29	8.82
Mwala	13.03	14.13
Kinangop	17.23	24.48
Ol_Kalou	8.59	10.90
Bahati	2.02	2.31
Molo	5.76	5.92
Njoro	4.41	6.63
Rongai	9.45	14.45
Mau	19.11	24.07
Githunguri	2.52	2.34
Kiambaa	2.53	2.03
Kikuyu	2.01	2.33
Lari	3.61	3.25
Limuru	3.09	2.63
Mean	***6.23***	

Breed: percentage of households keeping local, cross-bred and pure grade animals

Division	Local	Cross-Bred	Pure Grade
Kandara	0	26	74
Kangema	0	12	86
Kiharu	1	20	71
Gichugu	0	82	12
Ndia	7	43	45
Kasarani	9	0	91
Kangundo	79	2	7
Mwala	72	3	0
Kinangop	0	46	54
Ol_Kalou	0	37	60
Bahati	11	36	48
Molo	0	27	71
Njoro	5	54	41
Rongai	12	61	23
Mau	71	23	0
Githunguri	0	65	31
Kiambaa	5	52	33
Kikuyu	7	56	30
Lari	0	51	43
Limuru	6	15	64
Number of divisions where the breed is dominant	***3***	***7***	***10***

Sums of percentages do not always equal to 100 because of households who keep more than one breed.

Percentage of cropped land

Division	Percentage of cropped land	Std. Dev.
Kandara	99	1
Kangema	97	8
Kiharu	96	11
Gichugu	99	2
Ndia	99	3
Kasarani	100	0
Kangundo	98	7
Mwala	87	20
Kinangop	72	32
Ol_Kalou	89	14
Bahati	98	8
Molo	84	24
Njoro	93	15
Rongai	89	16
Mau	98	6
Githunguri	100	0
Kiambaa	100	0
Kikuyu	100	0
Lari	100	0
Limuru	100	0
Mean	*94.9*	

Labour for dairy activities: percentage of households in the division hiring at least one labourer mainly for dairy activities

Division	Percentage of households
Kandara	15
Kangema	25
Kiharu	13
Gichugu	20
Ndia	11
Kasarani	36
Kangundo	16
Mwala	35
Kinangop	38
Ol_Kalou	12
Bahati	13
Molo	17
Njoro	36
Rongai	22
Mau	36
Githunguri	16
Kiambaa	27
Kikuyu	24
Lari	18
Limuru	23
Mean	*22.6*

Percentage of purchased feed in total feed:

Division	%	Std. Dev.
Kandara	60	40
Kangema	38	43
Kiharu	47	39
Gichugu	51	48
Ndia	70	43
Kasarani	35	46
Kangundo	83	37
Mwala	33	46
Kinangop	49	43
Ol_Kalou	43	45
Bahati	54	46
Molo	61	42
Njoro	53	35
Rongai	41	44
Mau	0	0
Githunguri	87	21
Kiambaa	67	40
Kikuyu	68	41
Lari	84	26
Limuru	85	19
Mean	***55.4***	

Percentage of cash from sale of animals in total income from dairying

Division	%	Std. Dev.
Kandara	25	35
Kangema	34	39
Kiharu	29	39
Gichugu	44	44
Ndia	49	43
Kasarani	13	22
Kangundo	33	45
Mwala	41	47
Kinangop	25	32
Ol_Kalou	27	34
Bahati	12	24
Molo	25	30
Njoro	11	23
Rongai	16	30
Mau	67	34
Githunguri	16	26
Kiambaa	6	10
Kikuyu	9	19
Lari	25	28
Limuru	19	24
Mean	***26.3***	

Main milk outlet: percentage of households selling primarily to that outlet

Division	Individual consumers	Hotels and restaurants	Private traders	Organised marketing outlets
Kandara	41	13	46	0
Kangema	30	3	43	24
Kiharu	54	11	13	22
Gichugu	65	30	5	0
Ndia	44	6	25	25
Kasarani	70	20	0	10
Kangundo	81	5	0	14
Mwala	50	12	0	38
Kinangop	5	19	14	62
Ol_Kalou	19	3	28	50
Bahati	70	2	26	2
Molo	22	2	45	31
Njoro	56	18	21	5
Rongai	48	6	11	35
Mau	80	20	0	0
Githunguri	15	6	22	57
Kiambaa	11	17	50	22
Kikuyu	52	8	6	34
Lari	13	13	0	74
Limuru	0	7	0	93
Number of divisions where the outlet is dominant	***11***	***0***	***4***	***5***

Net Annual Cash Flows per farm (Ksh)

Division	Mean	Std. Dev.
Kandara	31 577	32 662
Kangema	26 427	45 423
Kiharu	48 059	156 301
Gichugu	59 539	175 808
Ndia	35 371	45 250
Kasarani	76 718	93 757
Kangundo	33 771	82 255
Mwala	106 326	291 422
Kinangop	44 377	51 157
Ol_Kalou	39 347	35 624
Bahati	39 644	53 244
Molo	30 034	39 152
Njoro	54 747	53 252
Rongai	62 617	151 879
Mau	47 454	42 849
Githunguri	44 561	135 663
Kiambaa	34 712	32 801
Kikuyu	36 162	32 443
Lari	14 839	28 296
Limuru	17 158	32 638
Mean	***44 172***	

Net Annual Cash flows per cow (Ksh)

Division	Mean	Std. Dev.
Kandara	25 900	25 420
Kangema	15 751	27 987
Kiharu	16 837	18 907
Gichugu	38 448	97 083
Ndia	29 344	47 220
Kasarani	14 324	14 344
Kangundo	30 002	84 581
Mwala	67 015	169 150
Kinangop	14 921	14 169
Ol_Kalou	16 214	16 935
Bahati	28 122	47 280
Molo	11 961	12 818
Njoro	35 190	34 630
Rongai	16 291	18 032
Mau	9 554	9 957
Githunguri	19 336	42 113
Kiambaa	23 452	29 592
Kikuyu	22 539	17 571
Lari	8 113	15 907
Limuru	12 495	27 742
Mean	***22 790***	

Net Annual Cash flows per ton of milk produced (Ksh)

Division	Mean	Std. Dev.
Kandara	14 054	19 349
Kangema	8 944	16 435
Kiharu	22 257	46 174
Gichugu	20 580	31 545
Ndia	18 137	19 849
Kasarani	10 123	10 559
Kangundo	18 870	30 423
Mwala	25 051	66 371
Kinangop	12 578	24 161
Ol_Kalou	15 223	19 729
Bahati	27 089	44 579
Molo	8 467	11 134
Njoro	17 000	19 964
Rongai	15 912	22 906
Mau	21 705	19 842
Githunguri	7 539	10 925
Kiambaa	6 843	17 891
Kikuyu	13 951	20 499
Lari	3 111	6 390
Limuru	10 583	29 832
Mean	*14 901*	

Annual returns per farm (Ksh)

Division	Mean	Std. Dev.
Kandara	47 287	35 245
Kangema	23 586	40 280
Kiharu	53 583	163 225
Gichugu	62 561	186 379
Ndia	49 895	50 434
Kasarani	- 1 674 122	5 103 538
Kangundo	50 705	92 576
Mwala	127 231	317 978
Kinangop	16 699	105 089
Ol_Kalou	55 130	39 170
Bahati	48 017	55 494
Molo	43 058	44 558
Njoro	63 858	51 515
Rongai	56 642	68 991
Mau	62 059	46 303
Githunguri	56 018	142 556
Kiambaa	44 418	33 384
Kikuyu	46 701	32 744
Lari	23 708	29 154
Limuru	27 396	32 749
Mean	***- 35 778***	

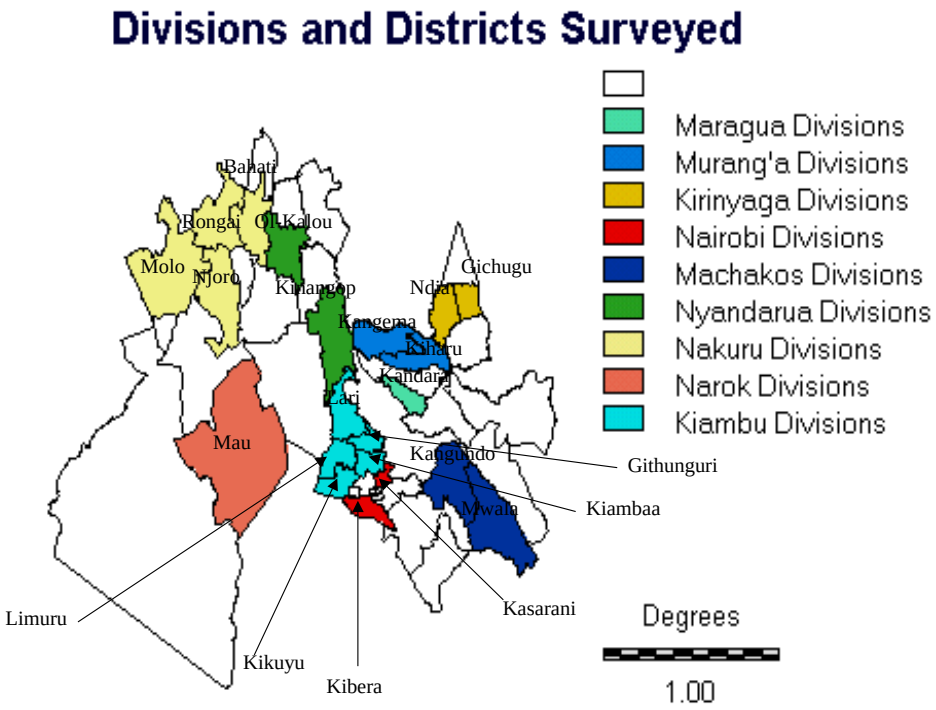
Annual Returns per cow (Ksh)

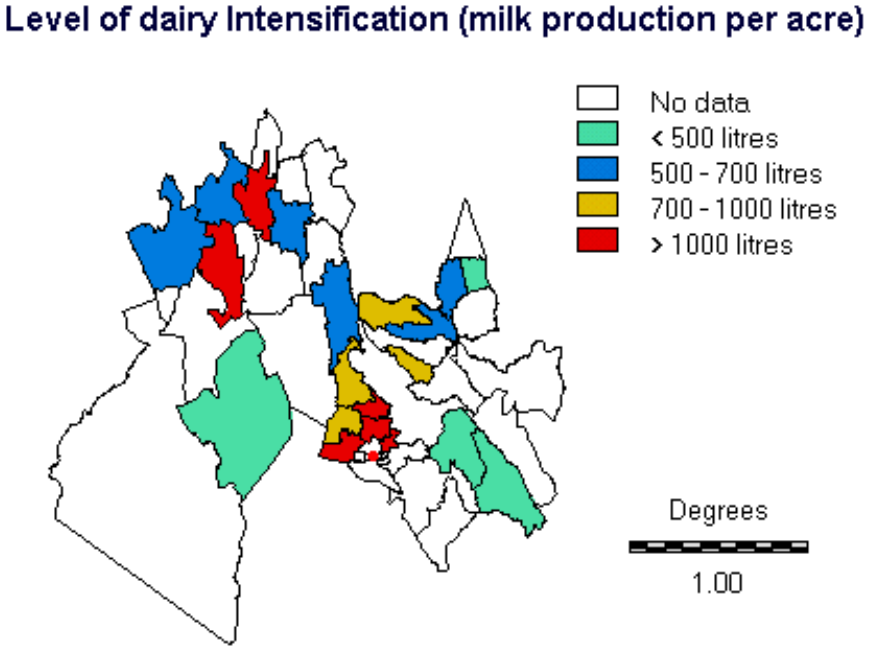
Division	Mean	Std. Dev.
Kandara	36 660	26 430
Kangema	17 460	28 047
Kiharu	20 899	24 935
Gichugu	36 819	98 699
Ndia	37 812	50 948
Kasarani	-38 843	107 187
Kangundo	44 932	96 538
Mwala	77 408	179 926
Kinangop	9 278	30 377
Ol_Kalou	23 104	18 283
Bahati	36 115	50 012
Molo	19 999	15 004
Njoro	40 946	34 116
Rongai	20 207	16 690
Mau	13 485	12 704
Githunguri	26 078	44 122
Kiambaa	30 715	32 261
Kikuyu	29 691	17 694
Lari	14 521	16 233
Limuru	21 278	30 817
Mean	***25 928***	

Annual returns per ton of milk produced (Ksh)

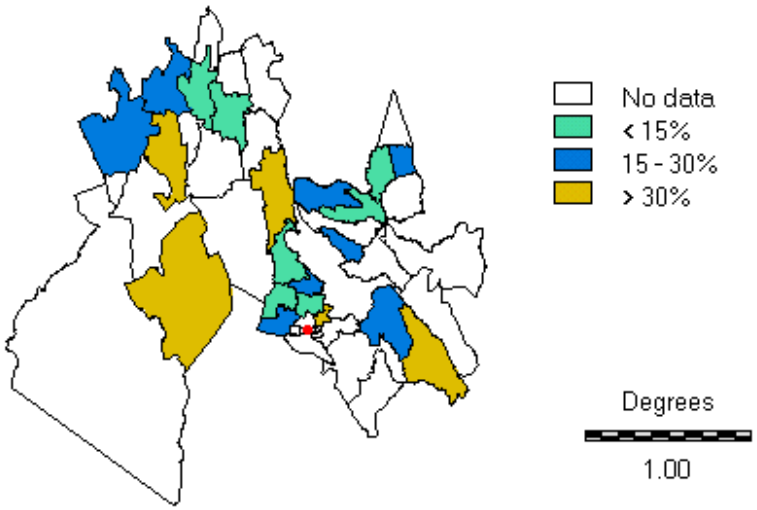
Division	Mean	Std. Dev.
Kandara	20 947	24 110
Kangema	10 762	17 097
Kiharu	25 304	49 085
Gichugu	23 706	31 764
Ndia	22 371	20 582
Kasarani	-1 031	30 222
Kangundo	34 462	35 190
Mwala	38 915	63 630
Kinangop	7 412	34 807
Ol_Kalou	22 851	26 142
Bahati	33 130	45 770
Molo	14 076	14 269
Njoro	30 291	21 196
Rongai	16 733	15 458
Mau	28 586	22 092
Githunguri	11 264	11 464
Kiambaa	10 439	19 260
Kikuyu	18 379	22 555
Lari	6 094	6 415
Limuru	9 716	8 959
Mean	***19 220***	

Annex 2: Maps showing the distribution of the variables in Annex 1.

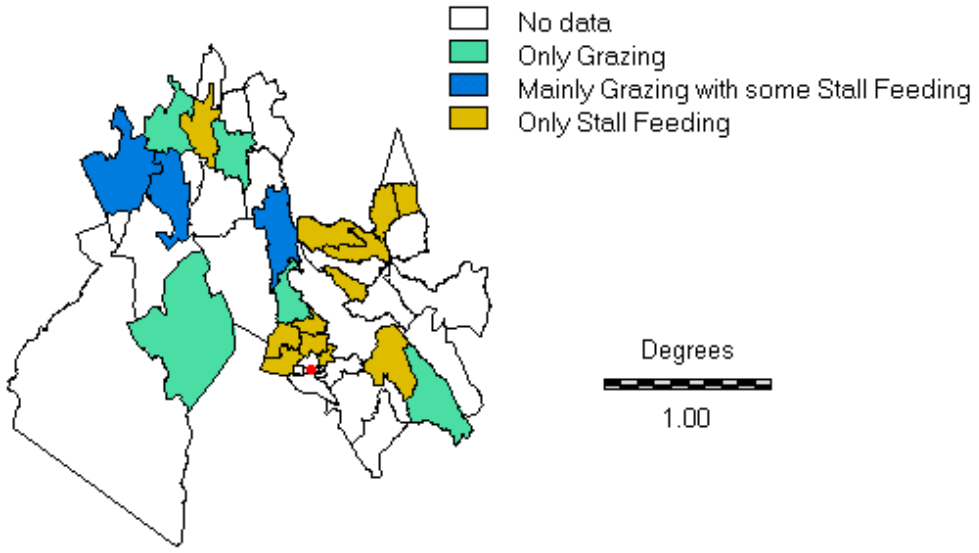




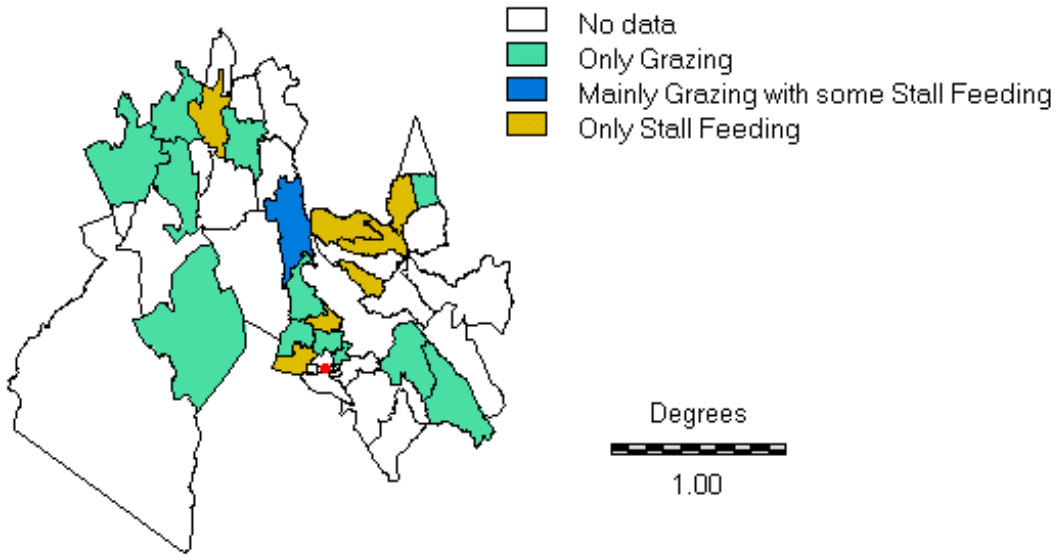
Percentage of Households Hiring Labour for Dairy Activities



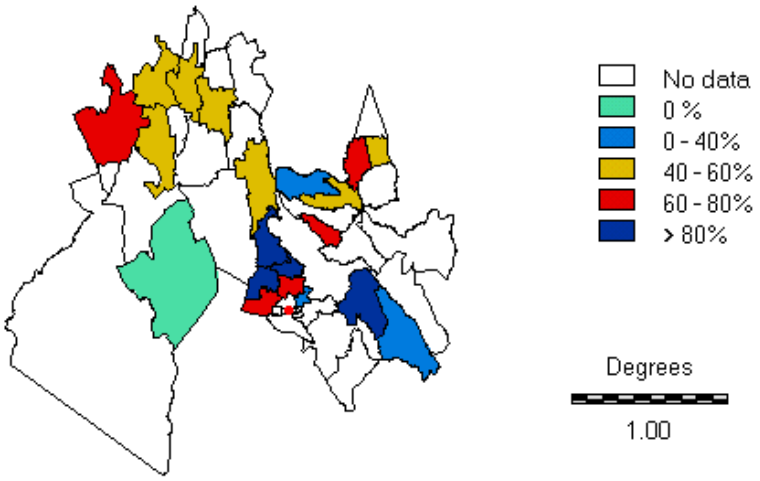
Main System for Keeping Cattle



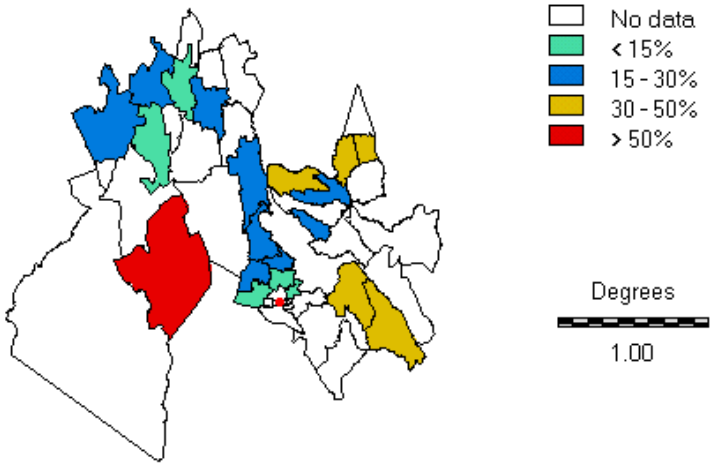
Main System for Keeping Cattle Ten Years Ago



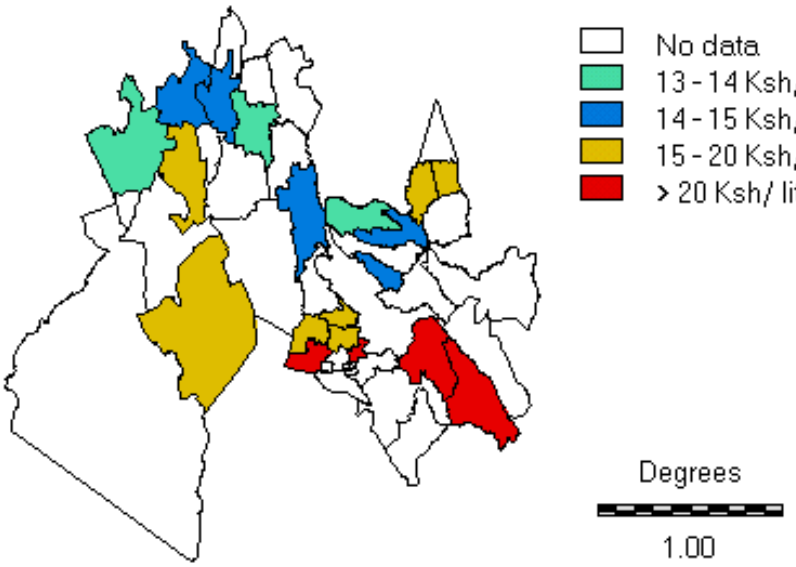
Percentage of Cost of Purchased Feed in Total Feeding Cost



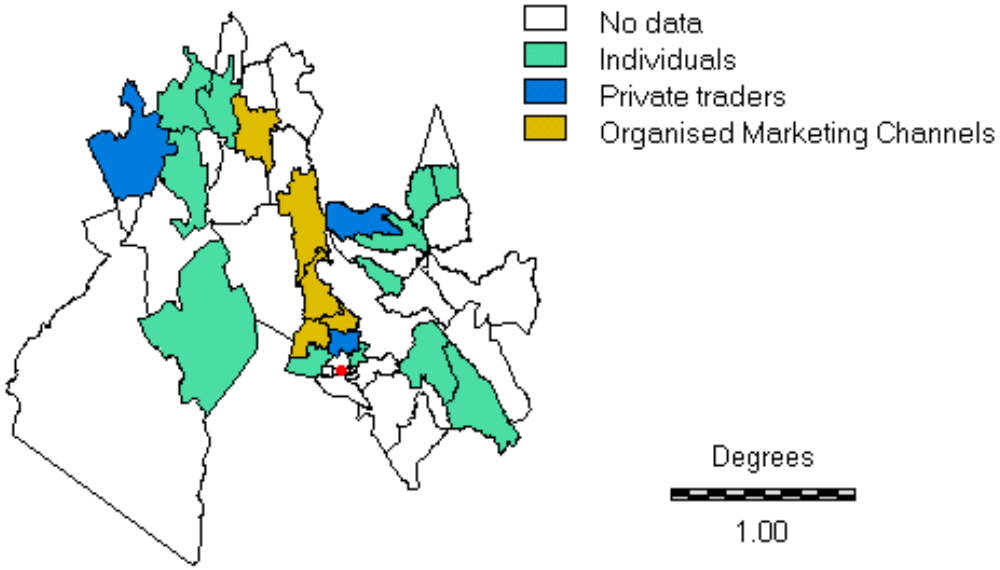
Percentage of Cash from Sale of Animals in Total Dairy Income



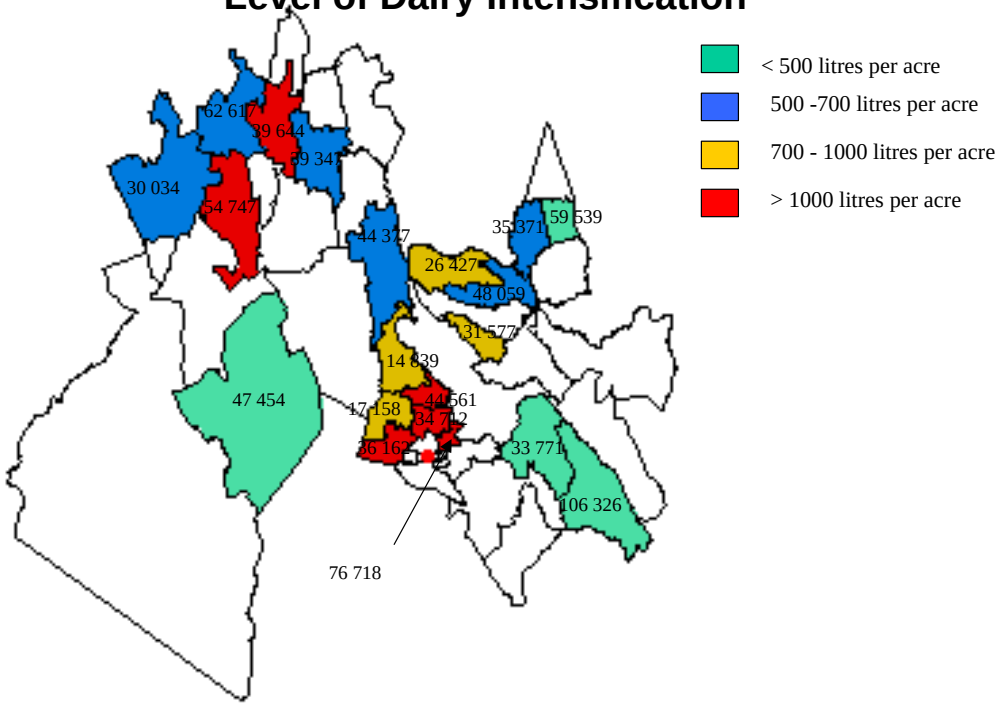
Average Milk Price per litre



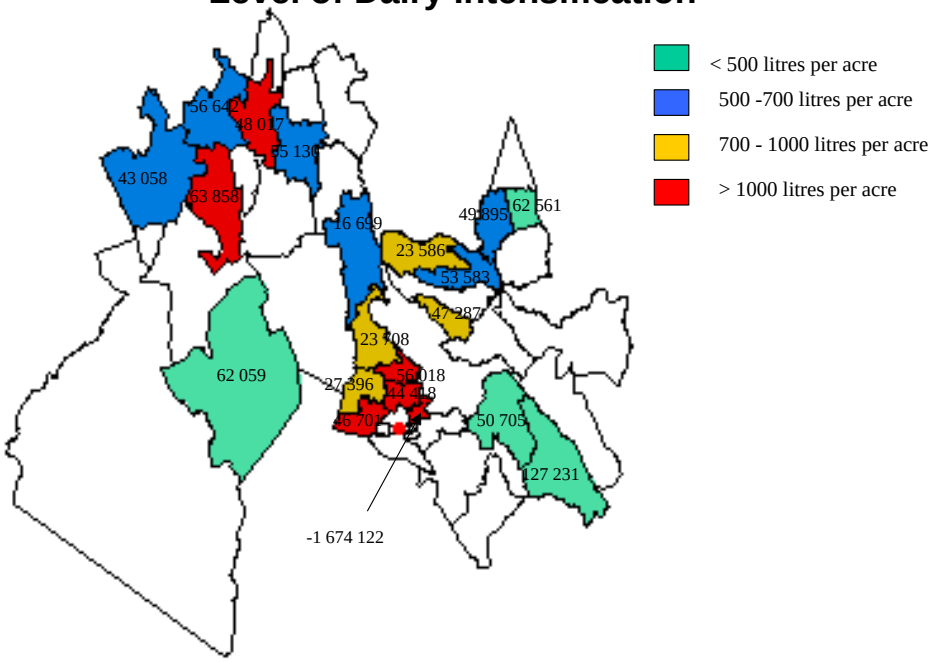
Main Milk Outlet



Annual Net Cash Flows per Farm (Ksh) per Level of Dairy Intensification



Annual Returns to Labour per Farm (Ksh) per Level of Dairy Intensification



Annual Returns to Labour per Ton of Milk Produced (Ksh) per Level of Dairy Intensification