Understanding the role of dairy in smallholder systems and the effect of intensification

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Introduction

In sub-Saharan Africa mixed crop-livestock systems predominate in the semi-arid, sub-humid and cool highland zones. In these areas, systems intensify and crops and livestock become increasingly integrated as the human population increases and land becomes a more important constraint than labour (Boserup, 1965; Mcintire *et al.* 1992). As intensification progresses, use of crop residues moves from open access to crop fields, following harvest, to labour intensive management of cereals as dual-purpose crops. Manure becomes a vital source of crop nutrients as scarcity of land precludes the use of fallow. Together with the stimulus of increasing demand for livestock products (Delgado *et al*. 1999), the trend is for systems to intensify, with output per unit of land increasing (Staal *et al*. 2000). In the Central Highlands of Kenya, smallholder dairy systems provide livelihoods for more than 50 per cent of agricultural households (Staal *et al.* 2002a). Farming systems are continually evolving in response to changes in available resources and access to market. In order to develop appropriate technologies and target extension advice it is important to understand how intensification and marketing opportunities influence the management strategies that farmers

adopt. The study presented here describes a longitudinal survey in four areas with contrasting systems representing different degrees of intensification, with different market potential.

Materials and methods

Site selection: Farms were selected from Central and Rift Valley Provinces (see Figure 1) to represent areas of high (HI) and low (LI) levels of intensification. Selection of the 21 farmers in each area was stratified to represent important systems observed during earlier characterization surveys in the region (Staal *et al*. 2002). In Central province (HI), in Kiambu District to the North West of Nairobi, farms were selected where coffee (n=11) or horticulture (kale, cabbage and green maize (n=10) were the main cash crops. In Rift Valley Province (LI) farmers were selected in Nakuru (n=11) and Nyandarua (n=10) Districts, where population density was lower compared to Kiambu and farm sizes generally larger. Market appeared to follow a gradient, with good access in Kiambu district in both areas with declining access as one moved from Kiambu to Nakuru and finally Nyandarua where problems of marketing milk were reported.

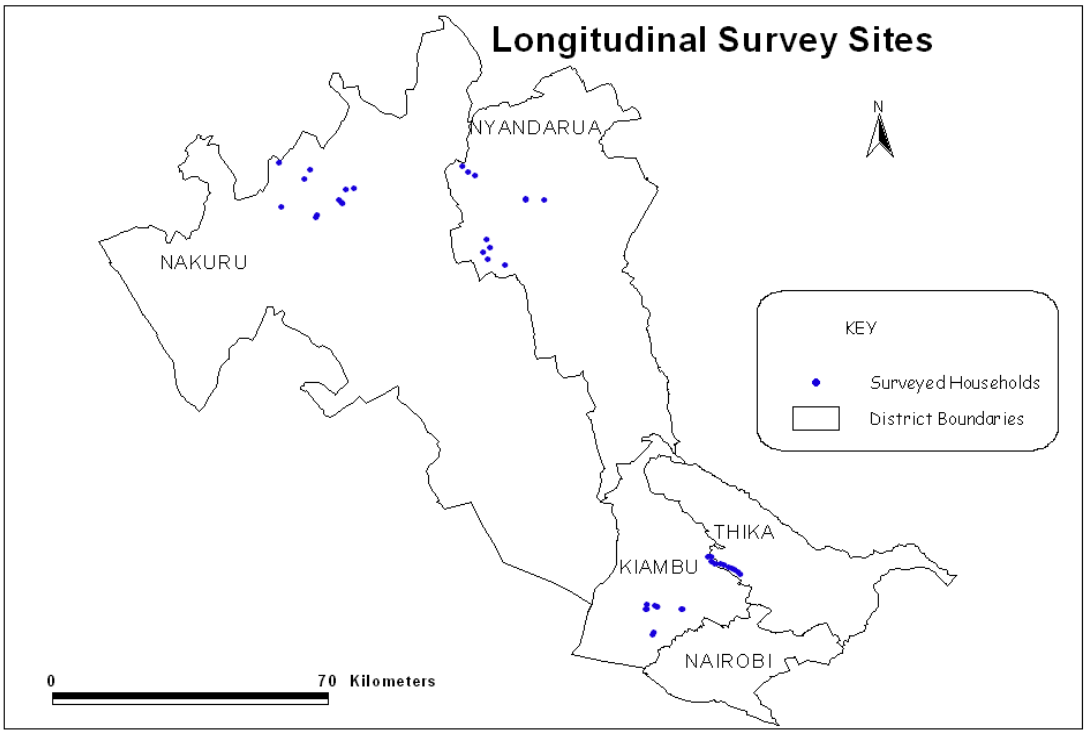


Figure 1: Location of Households Covered in the Longitudinal Survey

Data collection: In order to characterize the different systems, household parameters were collected including land size and numbers of cattle owned. All farms were geo-referenced and GIS layers used to estimate population density in a 5km radius of each farm. Market access was described as the total time to drive to the nearest market centre, taking account of different road types (Staal et al., 2002b) and was estimated using spatial data describing the road system in the surveyed areas. All farmers were visited twice weekly over a period of 14 months to collect data on farm management, production and marketing. Once a fortnight enumerators spent a full day on each farm recording quantity, type and source (on or off-farm) of feed offered to cattle during the day. Data collection took place from November 1997 to December 1998 in Central Province and from January 1999 to February 2000 in Rift Valley Province.

Data analysis*:* Characteristics related to individual households with no seasonal effects, including local population density, market access, land size and cattle numbers were analyzed using a mixed model (PROC MIX in SAS) where Intensification Group (IG) and System within group were considered as fixed effects with farm being the random effect. Milk production parameters were also analyzed in this way, with production per hectare representing an indicator of level of intensification. Seasonal effect on marketing in terms of the buyers, prices and milk sold were examined. The first 2 months data were not used in the analysis since they were taken as lead-in periods when enumerators were learning the data collection procedures.

Results and Discussion

Household parameters: Land sizes decreased as level of intensification increased. In Nakuru land sizes were only 60% of those in Nyandarua despite similar population densities suggesting a greater proportion of common land in the former. Numbers of cattle owned were lower in HI areas compared to LI areas (P=0.060) as expected, however, because of differences in land sizes, stocking density in Nakuru district was similar to those in the intensive sites. In HI areas a greater proportion had been planted to crops with little pasture or fallow, although with greater areas of planted fodders such as Napier (see table 1). The higher areas of planted cut and carry fodders reflect a change from grazing to zero grazing as farms intensified.

Table 1: Household parameters in areas of high (HI) or low (LI) intensification. Least square means are represented and means with different superscripts differ significantly (*P<0.05=*; <0.01 = **; <0.001 = ***; >0.05 = NS*)

Intensification group (IG)	HI		LI			
			Nakuru	Nyandarua	sed	Sig
Agro-ecological zone defined as accompanying cash crop	Hortic.	Coffee	Hortic./ coffee	Coffee/ wheat/ sheep	IG	IG
Household members	7.3	6.7	9.2	7	1.25	NS
Permanent labour (months/yr)	3.5b	1.5a	4.2b	4.5b	0.93	*
Casual labour (months/yr)	0.7a	4.4b	2.1c	5.2b	0.88	*
Paid labour (months/yr/ ha)	3.8a	3.1a	2.0b	2.1b	0.83	NS
Cattle owned (TLU)*	3.3	3.7	6.2	5.3	1.19	0.06
Stocking rate (TLU/ha)	4.8a	3.5ab	4.5a	1.7b	0.90	NS
Total land size (ha)	1.1a	1.9	3.2	4.6b	1.66	*
Agricultural land (ha)	0.39a	0.42	2.9	4.5b	1.58	0.01
Agricultural land (% of total)	86a	94a	76c	44b	7.9	***
Napier (ha)	0.24a	0.21a	0.12b	0.04b	0.06	**
Pasture and Fallow land (ha)	0	0	0.5a	3.0b	1.13	*

Intensification: Population density in HI areas was more than six times higher than that in LI areas, reflected by smaller farm sizes ($P<0.05$). Market access is better in the more intensive areas and as expected milk production per ha and labour use per ha increases as systems intensify (Table 2) although the increase for labour was not significant. Table 3 shows that as systems intensified farmers purchased more feed, with concentrate representing a much higher proportion of feeds offered. Proportion of crop residues used as feed was between 23-28% in all systems. This is considered to reflect the inverted U shaped relationship where crop residues increase then decline in importance as planted fodder and purchased supplements replace grazing at high population densities (Romney et al. 2004).

Table 2: Intensification parameters (HI) or low (LI) intensification. Least square means are represented and means with different superscripts differ significantly (*P<0.05=*; <0.01 = **; <0.001 = ***; >0.05 = NS*)

Intensification group (IG)	HI		LI			
			Nakuru	Nyandarua	sed	Sig
Agro-ecological zone defined as accompanying cash crop	Hortic.	Coffee	Hortic./ coffee	Coffee/ wheat/ sheep	IG	IG
Population density (persons /km)	763a	617b	101	96	24.3	***
Market access (minutes to market centre)	14.4	13.7	21.0a	45.4b	1.94	***
Milk Price (KSh)	19.4a	17.7a	15.0b	14.1b	0.92	***
Milk Production (l/farm/day)	7.2	8.9	13.1	11.3	3.47	NS
Milk Production (l/day/TLU**)**	2.3	2.2	1.8	2.4	0.39	NS
Milk production (l/day/ha**)**	12.3a	9.2ab	7.1ab	4.0b	2.27	*
Paid labour (months/yr/ ha)	3.8a	3.1a	2.0b	2.1b	0.83	NS

Table 3: Feed utilisation in areas of high (HI) or low (LI) intensification. Least square means are represented and means with different superscripts differ significantly **(*P<0.05=*; <0.01 = **; <0.001 = ***; >0.05 = NS*)**

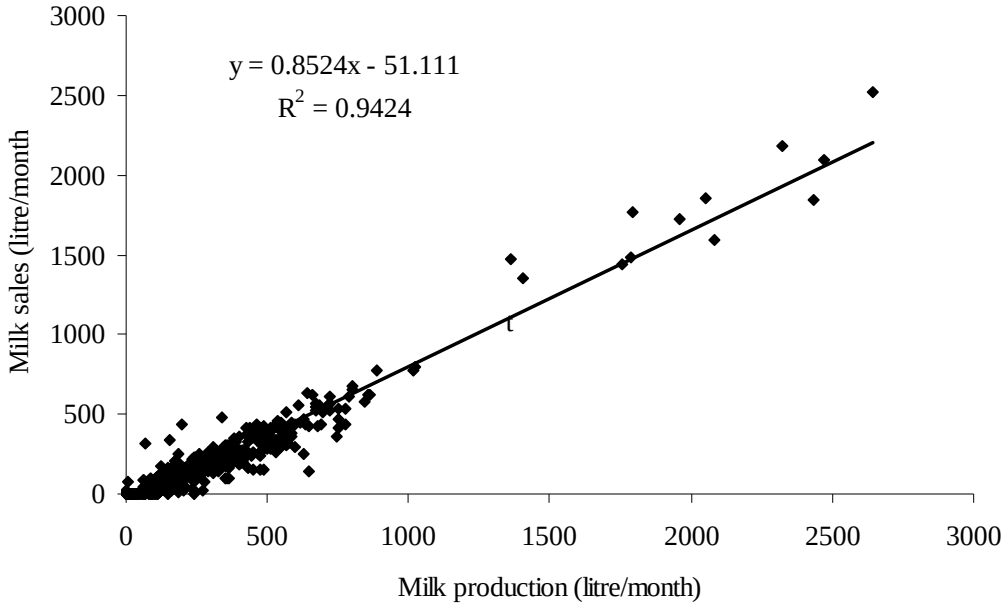
Intensification group (IG)	HI		LI		
			Nakuru	Nyandarua	sig
Agro-ecological zone defined as accompanying cash crop	Hortic.	Coffee	Hortic./ coffee	Coffee/ wheat/ sheep	IG
Feed kg DM TLU[1] day[1]					
Concentrate	1.44	1.04	0.31	0.15	<.0001
Crop residues	2.0	2.1	1.6	1.9	0.420
Other cut/carry fodder	0.8	0.5	1.0	1.1	0.185
Grazing	0.1	0.0	2.2	3.0	<.0001
Planted fodder	4.4	3.7	1.0	0.8	<.0001
Proportion of each feed type from off-farm sources					
Concentrate	0.84	0.88	1.01	0.99	0.020
Crop residues	0.25	0.14	0.33	0.16	0.448
Other cut/carry fodder	0.40	0.23	0.44	0.39	0.319
Grazing	0.17	0.27	0.51	0.42	0.161
Planted fodder	0.17	0.13	0.10	0.08	0.177
Proportion of all feed from off-farm	0.35	0.27	0.51	0.40	0.07
Proportion of all off-farm feed bought	0.80	0.98	0.44	0.38	<.0001

Source: Romney et al. 2004

Market access: Market access, which improved in the intensive systems, was expected to have a significant effect on management choices at the farm level. Buyer types were very different in the high and low intensity areas. In the high intensity areas, co-operatives accounted for 50 (Coffee) to 75 (Horticulture) per cent of all sales, with the rest being sold to shops and neighbours. In the more extensive area where there was no strong cooperative, farmers sold either to traders or private processors. In Nakuru farmers were closer to a main town, where many small traders can operate easily, and these market agents accounted for 65% of milk sold. In contrast, in Nyandarua where farms were difficult to access and far from the main road 71% was sold to private processors that collected milk from collecting points in small pick-ups.

A number of farmers reported throwing away milk during the season when milk production elsewhere in the country is at a peak because they were unable to sell it or consume it at home. This was not reflected in the data, with lowest volumes being collected by processors from July to October, a period when rainfall was low and milk production in Kiambu expected to be high. Another explanation for the fall in processor sales was that during the dry period the traders, who pay higher prices, easily accessed the farms when rains did not make access by road difficult. Amounts sold were directly related to the amounts produced (Figure 4). However, the average proportion of milk sold was similar in all areas (59, 56, 54 and 53 % in systems in the horticulture zone, coffee zone, Nakuru and Nyandarua respectively) despite the higher production levels per farm in the more extensive area.

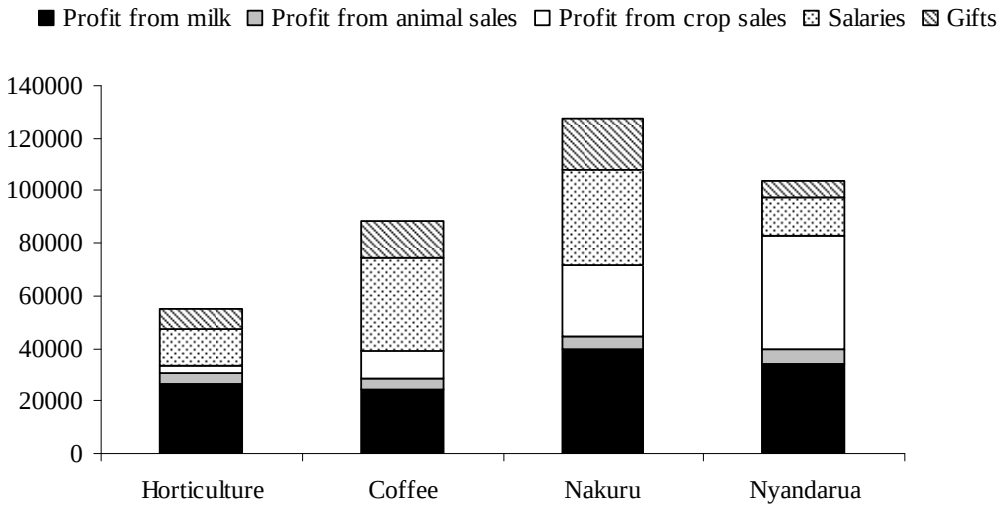
Figure 4: Relationship between monthly milk production against milk sales



Contribution of dairy vs. crops: Farmers grew a multiplicity of crops, mainly for subsistence. This shows lack of specialisation in production and a preference for maintaining a number of different enterprises. This may be a strategy to spread risk and maximize profits. In Kiambu, coffee and horticulture, were the main cash crops with green maize (young cobs harvested for roasting) being an important cash crop as well as dry maize. Other crops such as beans and Irish potatoes were mainly grown for subsistence. In Nakuru as well, production was mainly for subsistence but a large proportion of vegetables such as cabbages and kales were produced for the market. Nyandarua with large farm sizes, had a corresponding large proportion of farm produce destined for the market, with Irish potatoes and cabbages being the principal cash crops as well as pyrethrum. In all areas off-farm income, in the form of salaries or gifts was a significant proportion of total income. Only in Nyandarua did it fall below 40% of total income. Milk income represented up to 50% of total income with the

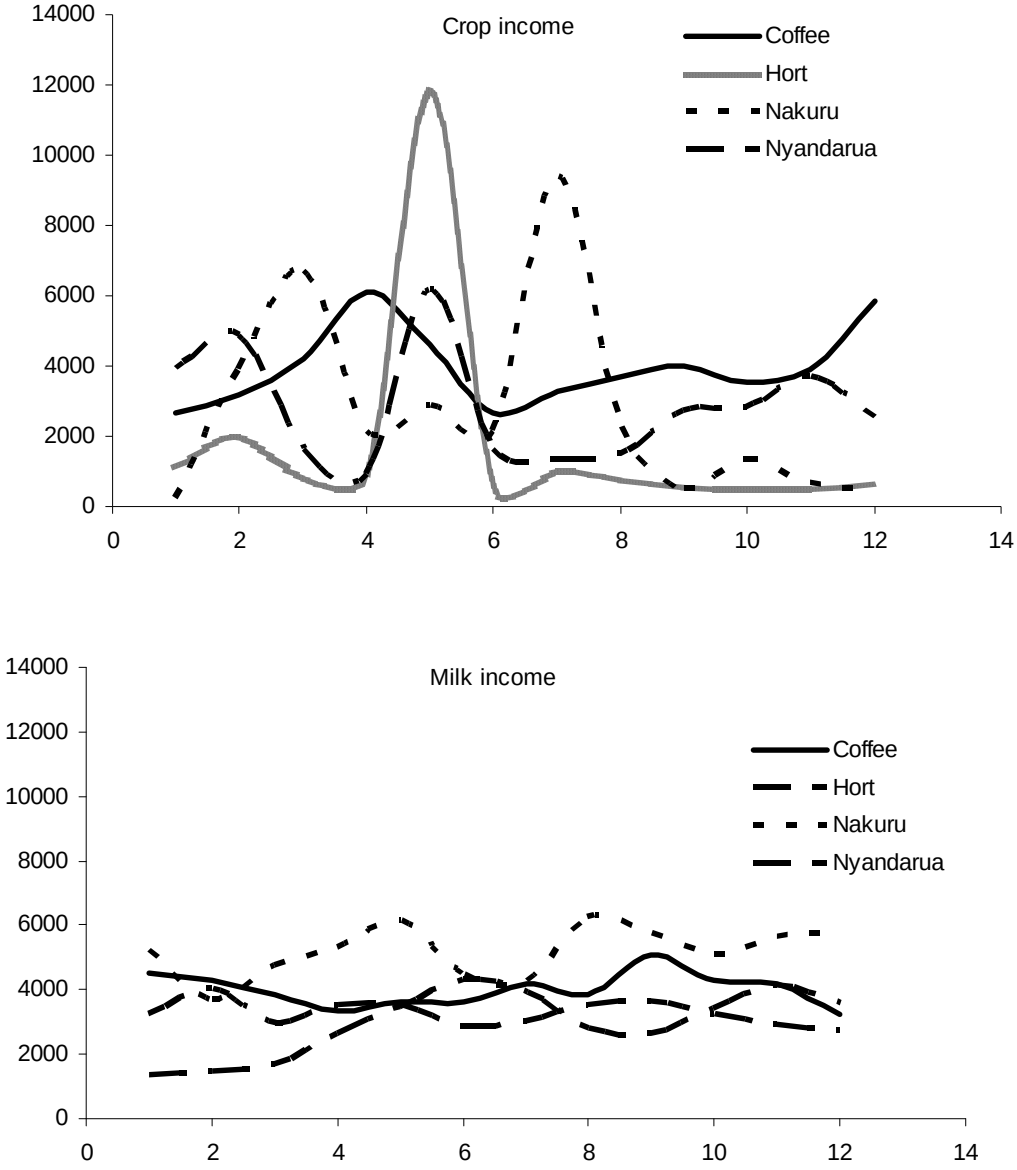
contribution to farm income increasing as farm size decreased and systems intensified (48, 62, 72 and 92% for Nyandarua, Nakuru, Coffee and Horticulture respectively) (Figure 5).

Figure 5: Relative contribution of different sources of on-farm income



Another advantage of milk sales as a source of income was that it was the more stable contribution to household earnings compared to crop sales which can be considered lumpy (Figure 6)

Figure 6: Seasonal variations in crop income –KSh per month



Conclusions:

With intensification, crop-livestock interactions become increasingly important. A key driver of intensification in Kenya is human population growth and the attendant land subdivision that it necessitates. Under intensified systems, farmers' strategies become geared towards

maximizing output per unit of land, the limiting productive factor. Crop-livestock interactions in intensive systems are important because they create significant economies of scope. The by-product from the livestock enterprise-manure is used in crops and the by-products from crop enterprise-crop residues are fed to the livestock. This relationship not only results to cost-savings, it also contributes to sustainable production because of the nutrient cycling it leads to. The increasing importance of dairy to overall farm income suggests that these farmers may be more willing to invest in technology that will make the dairy enterprise more efficient.

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