Introduction

With at least 3 million improved dairy cattle[1], most of which are kept by smallholder farmers, Kenya is one of the developing world's most successful milk-producing countries. Central to that success has been not only the strong local culture of milk consumption, but also the favourable agroclimate of its tropical highlands.

In areas of high population density, this has allowed the development of highly intensive smallholder dairy production systems typified by the 'zero-grazing' practice of confining and stall-feeding cattle with crop residues and planted fodder, particularly Napier grass. In areas of greater land availability, such as parts of Rift Valley Province, less intensive feeding practices of combined grazing and stall-feeding, or only paddock grazing, are employed. Thus, farmers choose feeding systems which best utilise their relatively most scarce resource: land in the case of zero-grazing, and labour in the case of paddock grazing. Costs of milk production in turn reflect this substitution of primary inputs.

Because dairy production forms such a significant part of the rural economy, accounting for 33% of agricultural Gross Domestic Product (GDP) (Omiti and Njoroge 2002), and is the

[1]Dairy cattle are here regarded as those with some significant degree (at least 50%) of exotic dairy genes. While cattle of all types, as well as goats, sheep and camels, produce milk for human consumption, by far the greatest proportion of the milk produced in Kenya is from dairy cattle.

primary source of livelihood for over 600,000 smallholder farm families (Omore *et al.* 1999), there is continual interest from the public and from policy-makers in the profitability and competitiveness of Kenya dairy production. This was particularly true during the mid-1990s to the early 2000s, a period which was characterised by economic stagnation and decline. Average annual growth in real GDP for the period 1996–2000 was only 1.8% (World Bank 2002). A number of studies in the 1990s estimated production costs and profitability of smallholder Kenyan milk production. For example, Sellen *et al.* (1990) estimated returns to smallholder dairy farming in Nyeri at KSh 3.10 per litre. In an update from the same District, Staal (1995) estimated profits of KSh 2.80 per litre in 1992. During the early 1990s, the National Dairy Development Project (NDDP) estimated the cost price of milk in Nyeri at KSh 7.00, suggesting a loss of KSh 1.84 per litre.

In 1992, Waithaka and Nijssen showed an average cost of KSh 7.04 per litre in 14 districts covered by the NDDP's zero-grazing project against producer prices of KSh 5.20. In 1995, Maina and Waithaka showed average costs of KSh 12.91 in 25 districts under the zero-grazing system.[2]

However, since the mid 1990s no reliable estimates of the cost of milk production in Kenya have been published. In the meantime, liberalisation of urban milk markets and reduced public support to livestock services have altered the structure of the milk market and, potentially, the relative prices of outputs and inputs. Owango *et al.* (1998) showed that real milk prices to farmers in central Kenya rose significantly during the early 1990s as a consequence of market liberalisation, but it is uncertain whether that trend has been sustained.

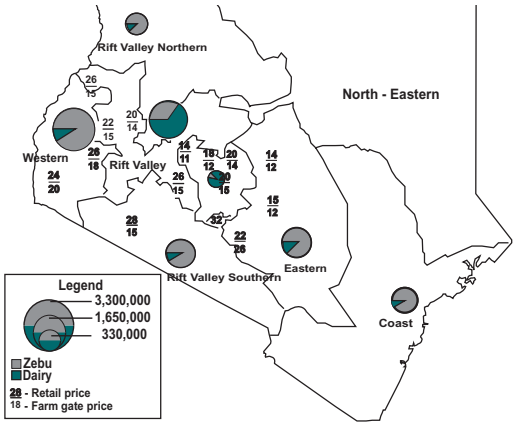
Given the lack of accurate information, it is useful therefore to re-evaluate the competitiveness and profitability of smallholder dairy production in Kenya. This report presents results based on data obtained from several detailed "longitudinal"[3] studies conducted by SDP in Kiambu, Nakuru and Nyandarua Districts between October 1997 and March 2000. Because budget data collection based on single-farm visits suffers from the difficulty of farmer recall over the entire annual period needed to capture seasonal changes, longitudinal monitoring was used to obtain more accurate data than is otherwise possible. The results presented in this report were derived from hundreds of observations over the course of an entire year for each of the farms monitored, and can thus be considered accurate data. In order to assess the potential impacts of the milk surpluses and low farm-gate prices subsequently observed in early 2002, follow-up surveys were conducted to update price information, and the budgets were updated to reflect new prices. Thus, this report presents both the results of the original surveys, based on complete data sets, as well as the results of the simulated budgets based on the new market prices observed in April 2002.

[2]Devaluation of the KSh in 1993 caused some costs such as dairy meal, to rise steeply, accounting for these differences in production cost estimates over a period of a relatively few years.

[3]Longitudinal studies refer to those that gather information from the same set of respondents through repeated visits over a defined period of time.

Determinants of milk prices in Kenya

FIGURE 1. Retail and farm-gate milk prices, and cattle populations by Province/Region, 1997.



Source: MoLFD and SDP figures, 1999.

Before addressing the cost of milk production and its profitability, it is useful to obtain a clearer picture of the factors that determine farm-gate milk prices across the rural areas of Kenya. Market prices are, of course, reflective of a number of supply, demand and policy factors. Not only do they reflect local supply and demand for milk, but also the costs involved in moving milk to larger demand centres in urban areas, which lower the prices received by farmers.

These costs include not only the cash costs of transport, labour and processing, plus a reasonable profit, but also the unobserved costs of the risks posed to buyers and sellers of non-delivery and non-payment, among others. Local supply depends on the density of dairy cattle and their productivity, which in turn depends partly on agroclimatic conditions, including rainfall and animal-disease challenge. Local demand is a function of human population density and milk and dairy product consumption habits. All of these combine to determine farm-gate and retail milk prices in a given area.

National milk price patterns

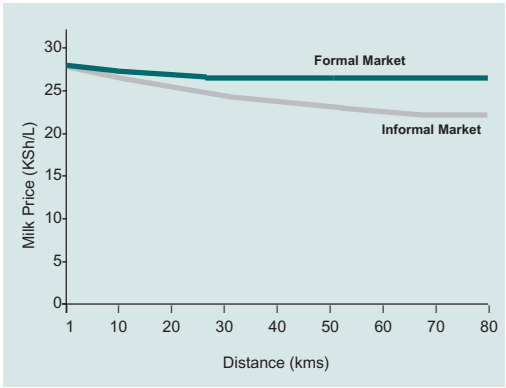
Figure 1 shows patterns of retail and farm-gate milk prices from key informant surveys conducted by SDP in 1997, and cattle

populations by province for the same period. Although absolute or nominal prices have changed since then, the patterns of price differences are likely to still be very similar. The highest prices were observed in the western parts of the country, which are known to be milk-deficit areas with high human populations and mostly zebu cattle populations, so that milk demand outstrips supply. As can be seen from the figure, however, the west also has the largest number of zebu cattle. Some of the lowest prices (farm-gate prices of KSh 11 or 12 per litre and a retail price of KSh 14 per litre) were observed in some parts of Rift Valley and Central Provinces where large dairy cattle populations and higher productivity contribute to sustained milk surpluses that have to be transported out to urban demand centres through intermediaries or processors.

Effects of distance on farm-gate milk price

In areas of significant milk surplus, where most milk must be transported to urban centres to be sold, transportation costs can have a significant effect on the price farmers receive for their milk. To examine this effect, SDP conducted a spatial analysis of milk prices using data obtained from separate large random cross-sectional household surveys in rural areas, as well as data derived from GIS (Geographic Information Systems) sources (Staal *et al*. 2001b). The formal[4] and informal[5] milk markets were considered separately, given the different market channels they follow. Using this analysis, estimates were made of the per-litre change in milk price for each kilometre of road that separated a farm from Nairobi. Figure 2 shows the distance decay functions estimated from the regression analysis of milk price formation expressed as a function of distance to Nairobi by main tarmac road. As can be seen, prices in the informal market fall more quickly with distance. In the informal market, at 75 kms from Nairobi, the effect of distance on milk price is maximum, with a fall in price of approximately KSh 6 per litre, which represents approximately one-fifth less than the mean informal market price in Nairobi (which is KSh 27.8 per litre). The maximum predicted fall in the formal market price is about KSh 2 per litre. These differences do not necessarily

FIGURE 2. Effect of road infrastructure and distance on milk prices in the formal and informal milk markets in Kenya.



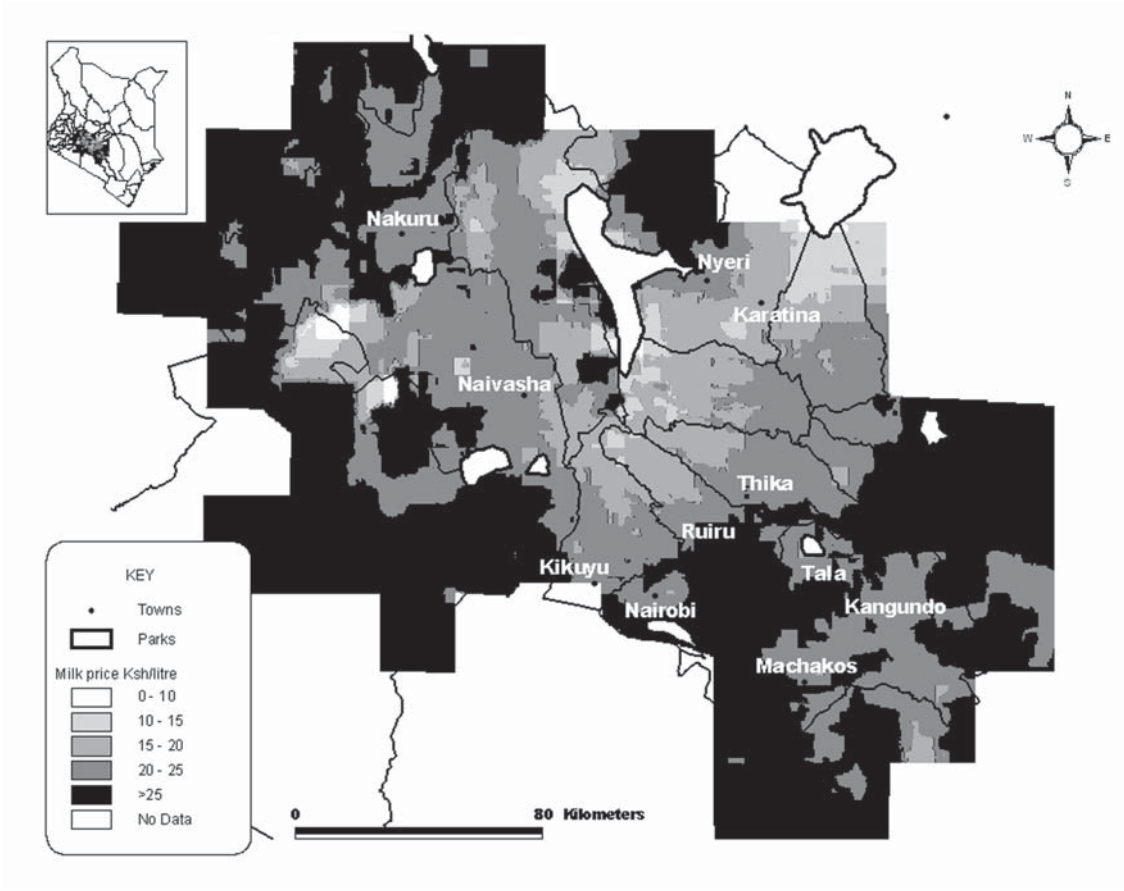
Source: *Staal et al. 2001b.*

[4] *Formal milk markets can be defined as those that follow modern Western-style processing technology, and conform to milk market regulations and licensing.*

[5] *Informal or indigenous milk markets can be regarded as those that handle mostly raw milk and traditionally processed products, and may not conform to all milk market regulations.*

suggest, however, that informal markets operate less efficiently per kilometre than formal markets, only that informal market prices paid to farmers more explicitly reflect actual transport costs and associated risks. This is because the formal market tends to offer uniform prices at the main collection centres, regardless of distance. The conclusion is that formal markets are important for providing reasonable milk prices over large areas. Informal markets, while offering higher prices to farmers, are limited in the range they operate, as they are unable or unwilling to subsidise the price for distant farmers, as the formal markets are effectively doing. The key point here, however, is that in the informal markets, on which most farmers in Kenya depend, distance to urban centres results in significantly lower farm-gate prices.

FIGURE 3. Predicted informal market farm-gate milk price in the area of survey, based on road distance and agroclimate (other variables held fixed at mean).



Source: *Staal et al. 2001b.*

FIGURE 4. Monthly milk prices received by monitored farms in the three study sites, weighted by volume.

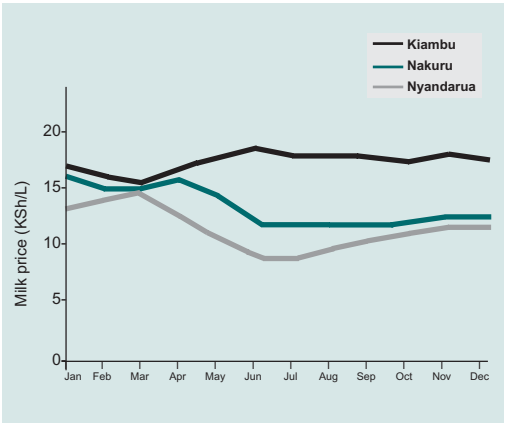


Figure 4 shows the seasonal patterns in milk prices observed among the farms monitored in the three study districts. As expected, prices fell during the flush seasons in Nakuru and Nyandarua, although prices remained steady in Kiambu, probably due to its easy access to strong urban markets. The largest seasonal differences occur in Nyandarua District, where the price in July was 19% lower than the peak price in March.

Based on the estimates of the effect of road distance on farm-gate milk price, GIS methods can be used to map the expected milk prices in different parts of the country. Figure 3 shows those predicted milk prices, based not only on distance but also on agroclimatic potential, which was measured using an index of rainfall and temperature. The map clearly shows the low milk price zones of Central and Rift Valley Provinces, with higher prices obtaining in outlying areas of higher milk deficit.

Seasonality in milk prices

An additional factor influencing milk prices is seasonality, primarily changes in rainfall that influence the availability of forages for dairy cattle. The season of peak milk production, or 'flush' season, is typically associated with the rainy season of April–June. During this period, increased supply tends to drive down prices received by farmers.

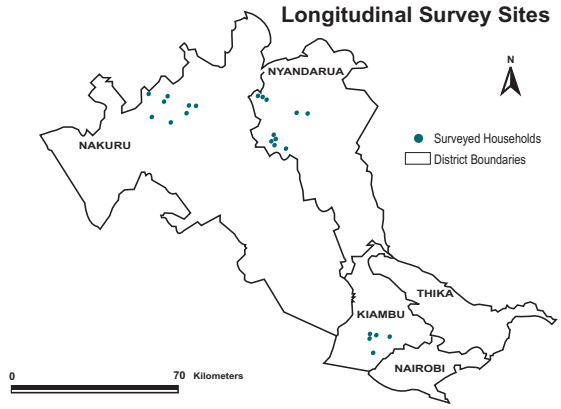
Data and methodology

Data sources

Data were gathered from representative dairy-farm households in the three study districts. The households were selected based on random cross-sectional surveys of 365 households in Kiambu (Staal *et al.* 1997), and of 1,390 households from across a number of districts in central Kenya (Staal *et al*. 2001a).

Combined principal-component and cluster analyses were employed to identify representative groups of dairy farms in terms of resources, market orientation and feeding strategy. From among those groups, a smaller number of typical farmers were selected based on their individual farm characteristics falling close to the mean for the group. A total of 21 farm households were selected and monitored from four divisions in Kiambu: Limuru, Kiambaa,

FIGURE 5. Map of survey sites with location of monitored households.



Githunguri and Kikuyu. In both Nakuru and Nyandarua Districts, 11 farms were selected and surveyed, all of them being from one division in each case: Rongai and Ol-Kalau, respectively. Figure 5 shows the location of these study sites.

An enumerator was assigned two, three or four farm households located within an area measuring no more than 5 km^2. The enumerator administered a structured questionnaire to each farm household twice a week from October 1997 to December 1998 in the case of Kiambu, and November 1998 to March 2000 in the case of Nakuru and Nyandarua, respectively. This was intended to ensure that seasonal variability in parameters such as prices, costs and fodder availability was captured. Based on farmer recall over the few days since the last visit, daily data were collected on the following: milk production, sales and consumption; milk-buyer type and prices paid to the farmer; quantities of feed and fodder used; purchase prices for feeds and other farm inputs; and cattle inventory changes through births, sales, purchases or deaths. In addition, data were collected on the amount of hired labour used and its cost, type

TABLE 1. Characteristics of the monitored farms: mean household values for some descriptive parameters.

Parameter	Kiambu (n = 21)	Nakuru (n = 11)	Nyandarua (n = 11)
Household members	7.2	8.4	6.3
Acreage per household	3.0	7.8	11.4
No. of dairy cattle	3.1	3.5	2.4
No. of cows	1.9	2.8	2.7
% of land under crops	86.1	55.7	27.6
% of land under pasture	2.6	35.5	70.7
% of land under other planted fodder	0	11.0	2.2
% of land under Napier grass	15.2	3.8	0.9
Annual cattle mortality rate (%)	18.5	23.0	19.6
Labour to the dairy activity (hr/yr)			
Hired casual labour	216	108	218
Hired long-term labour	216	901	673
Family labour	1,104	2,417	1,965
Milk utilisation (% of milk)			
Household consumption	21.3	21.0	29.5
Calves	8.1	9.1	13.7
Sales	70.6	69.9	54.8
Channel through which milk is sold (%)			
Local dairy or cooperative society	65.0	< 1.0	< 1.0
Private processors	4.0	23.0	72.0
Trader/hawker	7.0	64.0	21.0
Farmer group	0.0	< 1.0	2.0
Local households	7.0	2.0	5.0
Local milk bars/hotels	11.0	4.0	<1.0
Kenya Cooperative Creameries (KCC)	< 1.0	4.0	0.0
Neighbours	6.0	3.0	< 1.0