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# Economic contribution and viability of dairy goats: implications for a breeding programme

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**Abstract** To augment the incomes of smallholder farmers in Kenya and consequently improve their nutrition and income, many development organisations and policy makers are increasingly promoting dairy goat farming. Among the key organisations supporting the initiative is Heifer Project International—Kenya (HPIK). However, the economic contribution and viability of dairy goats under the HPIK project have not been studied so far. The aim of the present study was to determine the contribution of dairy goats to household income and the performance of the dairy goat enterprise using gross and net margins from dairy goat farming as an indicator of economic viability. A survey covering 71 farmers was carried out in the Coast, Nyanza, and the Rift Valley provinces of Kenya using a set of pre-tested structured and semi-structured questionnaires. Results showed that, on average, the dairy goat enterprise contributed, correspondingly, about 15.2% and 4.8% to the total livestock and overall household income and was viable. Differences in gross and net margins across agroecological zones were attributed to milk prices. Despite the existence of non-viable enterprises in two of the provinces, the few present suggest the possibility of obtaining reliable incomes from the enterprise. Redoubling of effort or re-orientation of production to match the local and external requirements would, however, be necessary. Costs and revenues were similar across the agro-ecological zones. Farmers with positive gross margins had better milk and stock sales and vice versa. The success of a dairy goat enterprise is attributed to location and good management. Besides, farmers' awareness of the market demands within and outside the community is important in establishing production goals and may be crucial to achieving a positive gross margin.

**Keywords** Dairy goats · Economic contribution · Economic viability · Smallholder · Kenya

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## Introduction

Initiatives to improve livelihoods of the smallholder farmers in Kenya have lately centred on the use of exotic dairy goats, either for upgrading indigenous goats or as purebreds. Dairy goats are a source of protein and income (Shirima 2005; Tadele 2007) and can fit well within the resource capacity of the rural farmers. The major breeds used are the Saanen, Toggenburg, Anglo Nubian, British Alpine, German

Alpine and their crosses. First introduced in Kenya in the 1950s by British settler farmers, dairy goats spread to the adjoining African farms through buck purchases that were used to upgrade the indigenous goats. Major development projects to improve the productivity of goat milk and meat were undertaken in the 1970s to 1980s. These were station-based and aimed at multiplying improved stock for farmers (Mwandotto et al. 1992). However, this was not largely achieved due to financial constraints (Rewe et al. 2002). When the German Technical Cooperation and FARM-Africa adopted community-based and farmer-led approaches in which genetic improvements were based on-farm in the early to mid-1990s, the dairy goat population rose significantly (Ahuya et al. 2005). The success of the community-based as opposed to the station-based approaches led to increased interest on the strategy by development organisations, including Heifer Project International—Kenya (HPIK), which initiated a dairy goat breeding programme in 1994 (Ogola et al. 2009). The increasing popularity of the dairy goat may be attributed to several factors, but it was assumed that the economic factor was paramount.

Interventions aimed at farmers must be financially viable to be successful (Kosgey et al. 2006). Low gross returns were a factor in the declining numbers for a particular goat species in Turkey as observed by Gürsoy (2006). Although gains have been made by community-based relative to the station-based approaches in expanding the dairy goat population in Kenya, both status and priority of the goats in national development compared to dairy cows are still low. Possible reasons are that their production was considered small scale and their products seldom found in the formal market. Lack of information on performance, profitability and income contribution to the household are other contributing factors. So far, no ex post analysis to evaluate the contribution and viability of the dairy goats provided by HPIK at farm level has been done. The present study aimed to understand the contribution of dairy goats to household income and their economic viability. Knowing the performance levels that have been achieved and the extent of variation in productive resources would enable comparison of the production levels with the potential for the particular system. This may assist in the identification of suitable avenues for further development.

## Materials and methodology

### Areas of study and sample selection

The data for this study was collected through a survey from a population of 71 beneficiaries of HPIK dairy goats in three agroecological zones. This sample size may be relatively small, but it represented a higher proportion of the farmers engaged by HPIK dairy goat breeding programme since its inception in 1994. The study areas were selected purposively (i.e. where HPIK had the dairy goat project). These were the Coast (Kwale district; agroecological zones 2 and 3), Nyanza (Homabay, Nyakach, Rongo, Siaya and Suba; low–medium agroecological zones 1 and 2) and the Rift Valley (Bomet district; lower agroecological zone 2) provinces (Ogola et al. 2009). From each district, farmers were randomly sampled from a sampling frame from the HPIK offices in the respective province, based on having reared goats for at least one lactation period. The economies of these areas were mainly based on subsistence farming, characterised by mixed crop–livestock production systems.

### Research instruments and data collection

Face to face interviews, personal observations, review of farmer-kept records and collections of secondary data whenever necessary and possible were used to fill in the questionnaires. The information collected was on-farm level quantitative and qualitative data such as demographic characteristics, production, marketing, purchase of inputs and costs and revenues meant to cover 1 year during the production period (the June 2006 to June 2007 seasons).

The contribution of dairy goat farming to the farm household income was assessed by the ratio of cash and in-kind income from dairy goats to cash and in-kind income from all enterprises, i.e. crops, non-farm income and income attributable to dairy goats. The units of analyses were the gross margin (GM) and net margin (NM). To establish the GM as the unit of analysis entailed finding the difference between the gross output and variable costs of production (Johnson 1990; Shirima 2005). For further analysis, the GM was expressed as per the most limiting resource in the enterprise such as hectare of land, labour or variable cost. Conversely, NM involved finding the difference between the GM and allowable fixed costs—in this

study, labour and depreciation (see, e.g. Johnson 1990).

The gross output of any farm was given by the sum of the monetary values of net meat production (i.e. goat transferred or sold) and milk offtake and manure utilised during the observation period (Ayalew et al. 2002). Milk production included the value of milk sold and that consumed by the farm household and the kid. Milked out yield was estimated from the vessels used for milk handling and the recordings of all lactating goats. This was multiplied by the prevailing market price of milk to determine the monetary value. Manure was taken as part of the gross output. Normally, manure is valued using available empirical evidence on the chemical composition and solubility of its key nutrients or the prevailing market price. However, for ease of calculation, the current study approximated this on the basis of number of wheelbarrows that would be filled and obtained the value from the prevailing market price of a wheelbarrow load. The goat's value depended on the prices of transfers made when being sold or 'passed-on'. Costs of production were the enterprise's variable costs. Bought-in feeds were calculated on the basis of the prevailing market prices, while non-priced items like the use of farm produced feeds and labour were calculated on the basis of opportunity cost.

### Data analyses

Data were analysed using Microsoft Excel package and other available statistical packages like SPSS. Content analysis consisted of describing, interpreting and analysing patterns, observing qualitative data and the causal relationships that these data generated. To find if observations were significantly different, *t* test ($P<0.05$) or analysis of variance was used. Gross and net margins, which are based on the simple theory of cost and returns, were used to calculate the rate of return of different factors of production. Descriptive analyses were used to work out the resource use structure and costs and returns in milk production.

## Results and discussion

### Income contribution of dairy goats

Table 1 presents the percentage contribution of livestock, crop and off-farm income to total income. The average net income for the surveyed households was Kenya shillings (KES; the currency of Kenya) 115,287 (the average exchange rate for June 2006 to June 2007 was US $1≈70 KES). Salaries, at 53.7% on average, were the biggest contributor to income. This was followed by livestock (31.7%) and crops (14.7%). These findings partly differ from those of Panin and Mahabile (1997) who found that the net revenue from livestock accounted for the greater share of income but was in agreement that contribution from crops, on average, was small. However, this pattern was not apparent when provinces were examined singly. In the Coast, the highest contributor of income was livestock followed by crops, and none of the respondents benefited from a salary. For the Rift Valley, livestock was the biggest contributor followed by salary and, lastly, crops. Salary was the biggest income contributor in Nyanza followed by livestock and then crops.

**Table 1** Percentage contribution of livestock, crop and off-farm income to total income per province

| Factor | Province | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Coast | | Nyanza | | Rift Valley | | | |
| Income source | Amount (KES) | % contribution | Amount (KES) | % contribution | Amount (KES) | % contribution | Amount (KES) | % contribution |
| Livestock | 51,736.10 | 56.1 | 18,134.30 | 18.1 | 69,884.21 | 43.5 | 36,242.20 | 31.7 |
| Salary | 0.00 | 0.0 | 71,720.90 | 71.7 | 69,157.90 | 43.0 | 61,943.70 | 53.6 |
| Crops | 40,472.20 | 43.9 | 10,178.40 | 10.2 | 21,698.40 | 13.5 | 17,101.30 | 14.7 |
| Total income | 92,208.30 | 100.0 | 100,033.60 | 100.0 | 160,740.50 | 100.0 | 115,287.20 | 100 |

**Table 2** Percentage contribution of livestock income by type across the three provinces

| Factor | Province | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Coast | | Nyanza | | Rift Valley | | | |
| Income source | Amount (KES) | % contribution | Amount (KES) | % contribution | Amount (KES) | % contribution | Amount (KES) | % contribution |
| Goats | 1,713.90 | 3.3 | 7,976.10 | 44.0 | 1,720.90 | 2.5 | 5,508.40 | 15.2 |
| Cows | 44,833.30 | 86.7 | 514.40 | 2.8 | 54,813.40 | 78.4 | 20,663.00 | 57.0 |
| Chicken | 411.10 | 0.8 | 1,491.90 | 8.2 | 3,190.50 | 4.6 | 1,809.40 | 5.0 |
| Other income | 4,777.80 | 9.2 | 8,151.90 | 45.0 | 10,159.30 | 14.5 | 8,261.40 | 22.8 |
| Total livestock income | 51,736.10 | 100.0 | 18,134.30 | 100.0 | 69,884.20 | 100.0 | 36,242.20 | 100.0 |

Dairy goats, on the average, contributed 15.2% to the total livestock income (Table 2). This was about three times more than poultry but over three times less than the contribution of dairy cows. The dairy goats provided 1.1–8% to overall household income, with the highest contribution in Nyanza (Table 3). The lower contribution in the Coast and the Rift Valley could be because dairy cows were a good alternative. This suggests that it may be more relevant to distribute the goats to those with no competing livestock. Generally, goats made an overall contribution of 4.8% to the household income (Table 3).

## Economic performance of the dairy goat enterprise

### *Enterprise revenue*

The overall total revenue came from milk, stock and manure sales. The provinces and farmers with and without positive margins were compared to determine the impact of revenue items on the dairy goat enterprise across regions. The results are presented under the sub-headings milk revenue, stock revenue and manure value.

### *Milk revenue*

Milk sales represented 56% of the total revenue. Apparently, the production objective of the dairy goat farming across the provinces was milk production. However, for the Rift Valley, milk and stock sales almost made similar contributions to revenue. This finding may have implications for the way animals are managed.

The milk revenue differed significantly across the provinces ($P<0.01$). Generally, milk revenue in Nyanza was greater than in the Coast and the Rift Valley. Further, the differences were significant between Nyanza and the Coast and the Rift Valley but similar between the Coast and the Rift Valley ($P<0.01$). Revenues between farmers with and without positive GM differed significantly ($P<0.01$). Farmers closer to urban settings had more opportunities for better milk prices and with more consistent demand.

**Table 3** Percentage contribution of dairy goat income to total income across the three provinces

| Factor | Province | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Coast | | Rift Valley | | Nyanza | | | |
| Income source | Amount (KES) | % contribution | Amount (KES) | % contribution | Amount (KES) | % contribution | Amount (KES) | % contribution |
| Goats | 1,713.90 | 1.9 | 1,720.90 | 1.1 | 7,976.10 | 8.0 | 5,508.40 | 4.8 |
| Total income | 92,208.30 | 100.0 | 160,740.50 | 100.0 | 100,033.60 | 100 | 115,287.2 | 100.0 |

About 47.9% of the farmers sold milk. Details on outlets for the milk, prices and modes of payment to farmers and the challenges farmers faced in selling the milk can be found in Ogola et al. (2009).

*Revenue from stock sales*

Stock sales represented 33% of the total revenue, and farmers incurred no cost during sale. Only 21.3% of the farmers sold stock. Sales were similar among the provinces, but revenues between farmers with and without positive GM differed significantly ($P<0.01$; Table 5). Farmers with positive GM attracted better prices for their stock. The price of goats ranged from KES 4,000 to 14,000. This was higher than the value of local goats that fetched KES 1,500–2,000. In total, 37 goats were sold for the period under the survey, bringing in an income of KES 212,000. The value of the goat compared to the value of the parent stock was low. The variation in the sales value was an indication of poor record keeping, lack of an organised market or market organisation with no standards. More males were sold compared to females (Ogola et al. 2009). Alam (2000) found that landless and marginal farmers (resource-constrained) sold their animals at an early age and with less market weight, as they largely depended on income from goats.

*Manure*

Manure value represented 11% of the total revenue. Manure values between Nyanza and the Coast and the Rift Valley were significantly different ($P<0.01$). The value of manure was higher in the Coast and the Rift Valley compared to Nyanza. The values were similar in the Coast and the Rift Valley. Apparently, location factors contributed towards some observed differences in manure revenue between Nyanza and either the Coast and the Rift Valley. The values of manure for farmers with and without positive GM were similar ($P<0.01$; Table 5).

*Enterprise costs*

The overall total variable costs (TVC) comprised the costs of feed, veterinary, labour and mineral supplements. The provinces and farmers who had positive and negative margins were examined to know the impact of cost items on the dairy goat enterprise across regions. The results are presented under the sub-headings of feed costs, veterinary costs and labour costs.

*Feed costs*

Feed costs consisted of costs of natural feeds, concentrates and mineral salts. These costs were calculated using actual cost of purchased feed or hay equivalent, depending on the situation. Crop residues were considered as substitutes to natural pasture hay. Results showed that, on average, feed costs accounted for 62% of the TVC. This agrees with the findings of Németh et al. (2004) for goat farms in Hungary that expenses on feed made the largest contribution to overall costs. Analysis of variance for feed costs revealed significant differences between the provinces ($P<0.01$). Further analysis showed significant differences between Nyanza and the Rift Valley ($P<0.01$). The feed costs between the Coast and both Nyanza and the Rift Valley were similar. The feed-related expenses accounted for 51–70% of the TVC in the Coast, 27–79% in Nyanza and 44–77% in the Rift Valley.

Table 5 shows that the average feed cost per litre of milk was least in Nyanza but greater in the Rift Valley province. The returns above feed costs were more in Nyanza than in the Coast and the Rift Valley provinces. This could be attributed to lower feed costs in Nyanza coupled with the favourable selling price for milk. For the Coast, the average milk production was higher, but the selling price for milk was lower than in the Rift Valley. Returns above feed costs were still, however, more favourable than for the Rift Valley. It suggests that farmers should be complemented with the right price for milk to recoup expenses on feed.

Feed costs between farmers with or without positive GM were similar ($P<0.05$). Generally, feed costs for farmers with positive GM were less and vice versa (Table 4). The land allocated for fodder to feed the goats were similar but with a lower trend for farmers with negative GM. Feed costs could, therefore, be an important factor in the viability of a dairy goat enterprise across provinces.

About 48% of the farms sampled supplemented their animals with concentrates, 61% of whom got positive GM. The cost of concentrates showed wide variation; this was determined by the relative availability, which was a function of proximity to relevant markets. However, costs were similar between the

**Table 4** Average economic performance of the dairy goat enterprise segregated by positive and negative gross margins (KES)

| Parameter | Gross margin | |
|---|---|---|
| | Positive | Negative |
| Revenue | | |
| Milk sales/home consumption | 9,580.24* | 1,310.06* |
| Stock sales | 6,565.24* | 3,080.98* |
| Manure value | 1,198.74 | 578.13 |
| Total revenue | 17,344.21* | 4,969.17* |
| Costs | | |
| Feed expenditure | | |
| Natural feeds | 4,185.26 | 4,442.77 |
| Concentrates | 815.95 | 850.31 |
| Minerals | 449.05 | 335.25 |
| Labour | 2,057.75* | 1,927.97* |
| Veterinary expenses | 1,388.28 | 1,346.89 |
| Sub-total 2 | 8,896.29 | 8,903.19 |
| Gross margin | | |
| Inclusive of roughage cost | 8,447.93* | −3,934.02* |
| Exclusive of roughage cost | 12,633.18* | 508.75* |
| Fixed cost | | |
| Depreciation and interest on stall | 1,204.27 | 1,510.31 |
| Depreciation and interest on equipment | 101.22 | 91.27 |
| Sub-total 3 | 1,305.49 | 1,601.58 |
| Net margin | | |
| Inclusive of roughage cost | 7,142.44* | −5,535.60* |
| Exclusive of roughage cost | 11,327.69* | 1,092.83* |

*$P<0.01$ (significant differences between those obtaining positive and negative margins)

provinces (Table 5). The same applied to farmers with and without positive GM. Of the 42% who did not use concentrates, 51% got positive GM. Most of these farmers fed the goats sweet potato vines. High-quality roughage reduces the amount of concentrates required. Low use of concentrates due to cost inhibitions also favoured feeding interventions using fodder trees and leguminous plants.

The use of concentrates was more in Nyanza than in the Coast and the Rift Valley provinces. Farmers in Nyanza spent less on natural feeds and less on concentrates but more on mineral salts than in the other provinces ($P<0.01$). The Coast and the Rift Valley spent similarly on mineral salt ($P<0.01$). This also applied to farmers with or without positive GM. Mineral requirements could possibly be a function of the feed quality and nutritional needs of the goat. The financial position of the farmer at any one time may also influence the amounts fed.

Chi-square analysis ($P<0.05$) established no association between concentrates and the GM. The GM for famers with or without use of concentrates was similar. Apparently, it did not matter if a farmer used concentrates or not. Low nutritive value of grazing resource and restrictive feeding of dairy meal may be the reason why the two feeding regimes were similar. Saving on feed costs through restrictive feeding may lead to less optimisation of the enterprise.

### *Labour costs*

Labour costs were computed from the opportunity costs and accounted for 21% of the TVC, 15–42% in the Coast, 9–48% in Nyanza and 13–30% in the Rift Valley. In more extensive systems, labour relative to feed costs tended to form a larger percentage of the overall total cost (Kumar and Deoghare 2000). Labour

**Table 5** Level of production to feed cost

| Parameter | Province | | |
|---|---|---|---|
| | Coast | Nyanza | Rift Valley |
| Average milk production in litres ($A$) | 365.63 | 321.57 | 281.09 |
| Average selling price milk in KES ($B$) | 16.67 | 34.30 | 19.68 |
| Value of product in KES $(A \times B) = C$ | 6,369.44 | 10,952.29 | 4,861.16 |
| Average cost of feed in KES ($D$) | 5,150.28 | 3,313.28 | 5,728.20 |
| Returns above feed costs in KES ($C-D$) | 1,219.17 | 7,639.01 | −867.04 |
| Feed costs in KES per litre ($D/C$) | 0.81 | 0.30 | 1.18 |

cost as a fraction of TVC varied a lot like all other previous costs but were similar across the provinces ($P<0.01$). Labour cost may possibly be the same, or the time spent by the farmers on goats would likely be similar across the provinces. However, labour costs between farmers with and without positive GM differed significantly ($P<0.01$; Table 4). Farmers with positive GM had larger tracts of land and spent less on labour and vice versa. Those with negative GM possibly spent more time seeking for pasture. Labour productivity per man day was low in almost all situations, implying that a dairy goat enterprise may not employ as such but provide supplemental income.

*Veterinary costs*

Veterinary costs comprised the actual value of purchased drugs and charges on treatment. On average, veterinary costs in the Rift Valley province were higher than that in the Coast and Nyanza provinces (Table 4). Costs accounted for an average of 16% of the TVC for the sample survey. Costs accounted for 4–24% of the TVC in the Coast, 2–35% in Nyanza and 5–32% in the Rift Valley. Although there was a wide variation of the overall contribution of veterinary costs to the TVC, the costs were similar between the provinces. The contribution of veterinary costs to TVC for farmers with positive GM was generally less compared to those with negative GM; their means were, however, similar.

*Enterprise viability*

The GM across the provinces differed significantly ($P<0.01$) when GM were calculated inclusive of roughage costs and vice versa (Table 4). This implied that fodder cost may generally affect GM. Nyanza differed significantly ($P<0.01$) with both the Coast and the Rift Valley, but the latter two were similar. Overall, the goat enterprise was viable both in the short and long term when all the provinces were pooled. Singly for the Coast and the Rift Valley, the goat enterprise was averagely not viable. In the Coast province, six out of nine farms were not viable, and in the Rift Valley, 11 farmers out of 19 posted losses. The GM for most farmers was positive; out of the 71 farms surveyed, 39 had positive GM. However, GM for some farms was disappointing, given the high genetic potential of the goats. The GM varied from KES −4,675 to 24,745 in the Coast, −6,810 to 33,837 in Nyanza and −7,491 to 15,930 in the Rift Valley.

The NM for the Coast province varied from KES −5,584.5 to 5,890, Nyanza −9,842.63 to 30,038.13 and the Rift Valley −10,548 to 15,137. Of the farms which had negative NM, six were found in the Coast, 18 in Nyanza and 13 in the Rift Valley. In total, 34 farms were viable, indicating that five farms that had positive GM became unviable enterprises on allocation of some fixed costs. On average, the NM was positive when all the provinces were pooled, but, individually, only Nyanza had an average positive NM (Table 4).

*Enterprise viability indicators*

Table 6 presents the dairy goat GM viability indicators across the three provinces. Nyanza had the highest GM/goat and per hectare. It also recorded the highest returns to investment, showing that it tended to be more economically efficient; of 43 farms,

**Table 6** Dairy goat enterprise viability indicators across the three provinces

| Viability indicators (KES) | Province | | | |
|---|---|---|---|---|
| | Coast | Nyanza | Rift Valley | Total |
| Average NM/goat | −930.80 | 3,499.09 | −2,140.34 | 1,428.39 |
| Average GM/goat | −190.50 | 5,068.92 | −666.77 | 2,867.33 |
| Average GM/ha | −632.65 | 40,018.35 | −6,245.72 | 22,484.88 |
| Average GM/variable cost | −0.02 | 0.65 | −0.10 | 0.36 |
| Average GM/enterprise cost | 0.01 | 0.17 | −0.01 | 0.10 |
| GM/feed cost | −0.01 | 1.17 | −0.28 | 0.63 |
| GM/man day | −0.02 | 2.04 | −0.36 | 1.13 |

**Table 7** Dairy goat enterprise viability indicators segregated by positive and negative margins

| Viability indicators (KES) | Positive GM | Negative GM |
|---|---|---|
| Average NM/goat | 7,142.44[a] | −5,535.60[a] |
| Average GM/goat | 8,447.93[a] | −3,934.02[a] |
| Average GM/ha | 63,491.70 | −27,492.20 |
| Average GM/variable cost | 1.04 | −0.46 |
| Average GM/enterprise cost | 0.29 | −0.13 |
| GM/feed cost | 1.80 | −0.78 |
| GM/man day | 4.01 | −2.37 |

[a] $P<0.01$

28 were viable. The return to investment cost of about 10% cent per each invested KES seemed low but was better than 1–3% of most commercial banks. However, if farmers were to rely on the banks with the cost of borrowing of between 16% and 23%, it would be difficult for them to instigate instant improvements on the dairy goat enterprise. Gross margins per labour cost were also extremely low. Staal (2002) reckoned that smallholder dairy production will remain viable as long as wages and opportunity costs remained low for whatever reason.

Table 7 presents the dairy goat GM viability indicators for farmers with or without positive GM. The return to investment cost of about 29% cent per each invested KES indicated that, on average, the provinces were only fulfilling a third of their potential. Evidently, with the cost of borrowing of 16–23%, it was possible for the smallholder to instigate instant improvements on the dairy goat enterprise if they wished using borrowed credit. Gross margins per labour cost were, however, low, implying there was room for improvement of the enterprise.

*Milk price analysis at gross margin level*

Table 8 shows the milk price analysis per litre at the GM level by making adjustment to the total cost equal to the value of goat and manure produced. Analysis of variance revealed similarities in the amounts of milk produced across the provinces. However, Nyanza and the other two provinces of the Coast and the Rift Valley differed significantly ($P<0.05$) in milk prices. Apart from income from kids and manure, the Coast and the Rift Valley sold their milk at a loss relative to Nyanza province. To break-even at the GM level, the Coast and the Rift Valley farmers should sell their milk at KES 33 and 32/kg, respectively. The alternative is reduction in cost of production or increased income through sale of more kids. One of the reasons why Nyanza province had an overall positive GM was because of the good milk prices compared to either in the Coast or the Rift Valley.

Farmers obtaining positive GM were able to recoup most of their costs through sale of dairy goats and simultaneously make a substantially large profit on milk (Table 9). Farmers with negative GM were largely disadvantaged by the milk prices; other factors were low income from manure and sale of stock due to lack of market and poor husbandry practices that led to high mortality rates.

**Table 8** The milk price analysis per litre at gross margin level across the provinces

| Factor | Province | | | |
|---|---|---|---|---|
| | Coast | Nyanza | Rift Valley | Average |
| Total expenses in KES ($A$) | 9,321.00 | 10,287.89 | 10,934.4 | 10,338.34 |
| Income from stock sales and manure in KES ($B$) | 3,741.19 | 5,296.30 | 5,358.19 | 5,115.73 |
| Margin of income over expenses in KES ($B-A$) | −5,579.8 | −4,991.6 | −5,576.21 | −5,222.61 |
| Average milk production in litres ($C$) | 365.63 | 321.56 | 281.09 | 316.32 |
| Cost price of milk in KES, KES, $D=(B-A)/C$ | −33.06 | −27.07 | −32.83 | −29.37 |
| Sale price of milk in KES ($E$) | 16.67* | 34.30*·** | 19.68** | 28.15 |
| Margin of sale price over cost in KES ($D+E$) | −16.40 | 7.23 | −13.14 | −1.21 |

Methodology adopted from Haenlein (2002)

*$P<0.01$ (significant differences between the Coast and Nyanza provinces); **$P<0.01$ (significant differences between Nyanza and the Rift Valley provinces)

**Table 9** The milk price analysis per litre at gross margin level between farmers with positive and negative GM

| Factor | Positive GM | Negative GM |
|---|---|---|
| Total expenses in KES ($A$) | 10,201.78 | 10,504.77 |
| Income from stock sales and manure in KES ($B$) | 8,472.64 | 2,206.58 |
| Margin of income over expenses ($B-A$) | −1,729.14 | −8,298.19 |
| Average milk production in litres ($C$) | 415.73 | 195.16 |
| Cost price of milk in KES, $D = (B - A)/C$ | −3.72 | −57.80 |
| Sale price of milk in KES ($E$) | 30.18 | 25.69 |
| Margin of sale price over cost in KES ($D+E$) | 26.45 | −32.10 |

## Implications for a sustainable dairy goat breeding programme

The current study established that the dairy goat enterprise on the whole was viable and may increase revenues and broaden the income base of smallholder farmers. There was adequate demonstration of the role of dairy goat farming in sustainable development in different agroecological zones because even where the overall GM was negative, there were farmers with positive GM. Policy makers and extension personnel can, therefore, encourage farmers to adopt the enterprise across regions. Variations existed in the economic performance of the goats across agroclimatic zones on consideration of feed costs and milk prices. Because of the higher percentage to total costs, feed costs strongly influenced the gross and net margins. Caution is, however, required with the use of opportunity costs for the valuation of fodder for farms that may make decisions on the enterprise using production cost of fodder, which tended to be lower. The enterprise was not doing well in the Coast and the Rift Valley provinces. This was traced to low milk sale value, attributable to lack of organised marketing and competition from cows' milk. More labour time directed towards the activity could translate to higher returns, possibly due to fewer disease incidences and better feeding of the goats. Categorisation of farmers into those having positive and those with negative gross margins revealed that farmers had still not fulfilled their potential. Cost factors with respect to depreciation could not be considered due to lack of reliable data on the productive lifetime of the goats, resulting in further reduction of the gross and net margins.

It is important to note the partial adoption or application of certain technologies or practices possibly due to a low capital base or revenue, as exemplified by the use of concentrates and possibly mineral salts and drugs. Additionally, complications possibly brought about by incompatibility with normal practice whereby managing dairy goats involved regular deworming, spraying with acaricide and management of fodder through weeding, fertilisation and harvesting while no management is provided to local goats may have further contributed to affecting productivity.

To improve on performance and output of dairy goat production as a development strategy, the following recommendations were drawn from the study:

- Exploitation of contrasts and the complementary roles of different areas within a region (i.e. integrated development) should be enhanced to increase the overall productivity from the region. For example, Nyanza province was a milk deficit area and pressure of land limited the raising of large stock. The success of dairy goat promotion was attributed to better milk prices. Areas where dairy goats' milk supplemented the cows' received low prices. Alternatively, these areas may be used for breeding/multiplication to supply goats for areas with limited land.
- Strengthen extension services, possibly through a policy enacted by the government given that most farmers were not fully exploiting the potential of the dairy goats. This would assist farmers who were not viable by the establishment of technical special teams to help them through specialised courses on dairy goat management. Special extension and rural education programmes should cover farm organisation, financial management, marketing aspects and application of recommended practices, coupled with farm demonstrations that incorporate research institutions to provide farmers with more opportunity to learn about dairy goats. Integration of rural extension services

among extension providers may assist in avoiding duplication and wasting of resources as well as addressing linkages.
- Enhance group meetings to exchange ideas that could assist in the diffusion of successful dairy goat farming practices.
- The situation of producers in the country needs to be assessed against other livestock production sectors. Experiences from existing support regimes in other countries are required to help guide the local dairy goat sector.
- Achieve efficiency by linking production and post-production components to efficient services and marketing schemes. One way of establishing this is by initiating the development of an organisation of producer and marketing groups that will encourage distribution and marketing of dairy products and goats.
- Government support for fair commodity prices and towards the establishment of an effective integration of market from primary producer to final consumer as well as develop standards that guide the industry. This suggests that the most effective and sustainable means of helping the sector lies in developing the market, communicating with consumers, highlighting the nutritional and health benefits of the products concerned and boosting consumption.
- Further research is necessary on labour studies to understand the time spent by individuals in carrying out specific tasks and whether it has an impact on productivity and by extension gross margin. There is also need to carry out research on the productive lifetime of dairy goats. Additionally, research should be undertaken on how structural characteristics and production orientation of the systems relate to the sociological and information seeking characteristics of the farmers. These aspects may play a substantial role in determining the management intensity under which the systems operate. There is also need to research on alternative technologies that may be cheaper to adopt, especially for technologies that involve cost on consideration of agroecological zones.

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