

Effects of Dry Matter Yields Variability on Milk Production and Live Weight Changes in Dairy Cattle in Coastal Lowlands, Kenya

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ABSTRACT

Feed quantity and quality are inadequate and rarely meet the nutrient demands of lactating cows especially in the dry seasons in the Coastal Lowlands of Kenya. The objective was to determine the seasonality of dry matter yields and utilization of feed resources and their effects on milk production and live weight changes on cattle production in Coastal Lowlands. A longitudinal survey was carried out for 12 months on a purposive sample of 32 farms. The estimated annual on-farm feed production and animal requirements was 3,865 tonnes DM/year and 5,004 tonnes DM/year respectively with a deficit of 1,139 tonnes DM/year. The annual on-farm feed DM production met cattle requirements during season IV when there was a surplus of 54.1 tonnes DM. The mean live weight change (MLWC) ranged from 168 - 268g/day for season III and season IV respectively. The average milk production (AMP) ranged from 4.7 - 5.6 liters/cow/day for season III and season I respectively. Pooling available feed resources for 12 months through appropriate storage and carry-over between seasons decreased MLWC from 268 - 257 g/day in season IV but increased from 264 - 274; 261 - 278 and 168 - 187 g/day in seasons I, II and III respectively. The deficit in DM availability during the dry season could be remedied through conserving surplus feed during the wet season. These results could be used to develop an integrated forage production and livestock nutrition management plan to provide sufficient year-round feed supply based on animal requirements and supplementation strategies.

Keywords

Feed deficit, Seasonality, Pooling.

Introduction

Background information

The Kenya dairy sector contributes 4% of the national gross domestic product (GDP), 14% to the agricultural GDP and 40% to the livestock sector GDP and employs 1.2 million people either directly or indirectly along the production value chain [1]. This underscores its importance in contributing towards poverty alleviation and food and nutrition security in both rural and urban areas. Small-scale farms play an extremely important role as they produce about 80% of Kenya's total milk production. Kenya small-scale dairy production is regarded as a successful and vibrant industry due to the growing domestic milk production, processing capacity, per capita milk consumption and export potential [2].

Farmers in Coastal Lowlands of Kenya mainly depend on rain-fed forage production for their livestock [3-5]. The rainy seasons are associated with high biomass production and animals are fed on a variety of feeds, including weeds from the arable land while the planted forages are spared for the dry season [4]. The reliance on rain-fed forage production leads to forage scarcity during the dry months of January to March and July to September. The poor condition of forage is usually attributed to the poor performance of short rains which is significantly depressed, poorly distributed in time and unevenly distributed in space. Low quality crop residues including maize stovers, mixed pasture grasses and dry grass from fallow land are then often the only feeds available to livestock [6].

In response to the seasonal variations in both quality and quantity of feed availability, there is an overall reduction in dairy cattle productivity characterized by low calving rate, low calf birth weight, high calf mortality, low weaning weight, reduced mature

body size and more importantly low milk production [7]. It is also noteworthy that livestock keepers keeping a large number of animals beyond the carrying capacity of the land is associated with high risks of losses from death of animals during prolonged dry seasons and droughts [8], a common phenomenon in the Coastal Lowlands of Kenya. These constraints amongst many other institutional and infrastructural limits not only the ability of producers to meet their milk requirements but also pose a threat to their livelihoods. Therefore, consideration of seasonal distribution and selective utilization of feeds are important factors in the assessment of cattle production systems in the area. Hence, the objective of this study which was to evaluate the relationships between seasonal feed availability (quantity and quality), live weight change and milk yield in the Coastal Lowlands of Kenya.

Materials and Methods

Study Area

A longitudinal survey was conducted in the Coastal Lowlands of Kenya (Kwale and Kilifi counties) which fall in over five agro-ecological zones characterized by different climatic, topographic, soil, and other environmental features that influence the potential of agricultural development [9]. Feed production was based on a purposive sample of 32 farms for 12 months visited fortnightly. To avoid biased observation, visits were done on an *ad hoc* basis by enumerators. Prior to commencement of data collection, farmers were trained on how to sample feeds and weigh feeds offered to animals.

Farm Forage Production and Utilization

Detailed specific farm forage production and utilization information was captured in order to analyze the seasonal changes on availability. The farms were visited every two weeks by trained enumerators to collect data on feeds (quantity, quality and source i.e. on-farm or off-farm). The feed resources included purposely grown fodders/ pastures such as napier grass, legumes, crop residues, roadside grass, cereal milling by-products and Non-Conventional Feed Resources e.g. sea algae. For determination of forage production, 150 plots were selected in different farms at harvesting time during season I (long rains dry season from January - March), season II (long rains season from April - June), season III (short rains dry season from July - September) and season IV (short rains season from October - December).

The yields for each of the standing forage were assessed from a 2m x 2m plot by hand cutting at ground level using a sickle. Forage from each plot was weighed and two samples collected in separate paper bags. The grass samples for yield determination were collected shortly before grazing. To determine the species composition of natural pastures, 2 diagonal transect lines were laid out in each pasture field in each of the farm. Along each transect line; five regularly spaced 1m² quadrants were thrown. In each quadrant, the relative composition of different plant species was determined, clipped and weighed. Dry matter (DM) content was determined by drying the samples in an oven at 105°C for 5 hours. The dry matter yield per hectare was computed per type of fodder and per farm by adding the yields from each of the plots with a

particular fodder. The information collected was used to depict the seasonal availability of forage across the year.

Results and Discussion

Land resources management

The mean total land size, utilization and distribution classes by gender of household head and county varied considerably as shown in Table 1. The total land size, napier grass, maize and natural pastures were significant ($P < 0.05$) by county (Table 1). The mean acreage under maize was 1.8 acres with a range of 0 - 8 acres. Households in Kwale County had larger ($P < 0.05$) average landholdings (7.7 acres) compared to Kilifi County (4.4 acres). This was consistent with the findings of [3] who observed that farmers in Kwale had larger farm sizes (mean 10 acres) than in Kilifi County (mean 8 acres). The overall mean land size was 5.3 acres and ranged from 0.25 - 30 acres. The current acreage was higher than the reported mean agricultural land holding of 3.8 acres for Coastal Lowlands. Earlier studies reported a much higher per capita land-holding of 27.2 acres (11 ha) [10] and 10.9 acres (4.4 ha) in Kilifi [11,12]. However, [13] reported smaller land sizes for Kwale at 3.6 acres and larger land sizes for Kilifi at 6.6 acres and attributed this to land tenure system where in the former the farmer owned all the land they occupied and in the latter 14% of the farmers were in family land which had not been subdivided. The lower land-holding sizes in the current study for the two counties indicates an increase in human population density and much more for Kilifi County. Of the respondent households, 68.4% had less than 6 acres, 20.3% had more than 6 - 11 acres and 11.3% had more than 11 acres.

Table 1: Total land size, utilization and distribution classes by gender of household head and county.

Land (acres)	Household head		County		Whole sample				(%)
	Female	Male	Kilifi	Kwale	Overall	S.D*	Mini	Maxi	
Total land size ^a	5.1	5.3	4.4	7.7	5.3	4.9	0.25	30	100
Napier grass ^a	0.8	0.7	0.6	1.0	0.7	0.8	0	5	13.7
Maize ^a	1.7	1.8	1.5	2.7	1.8	1.5	0	8	34.1
Natural pastures ^a	2.6	2.8	2.3	4.1	2.7	3.6	0	26	52.2
Land distribution classes (%)									
< 6 acres	66.9	68.4	68.4	53.3	68.4	-	-	-	-
6-11 acres	18.8	22.6	20.3	23.8	20.3	-	-	-	-
> 11 acres	14.3	14.2	11.3	29.2	11.3	-	-	-	-

^aSignificant at $P < 0.05$ by county' *S.D is standard deviation.

Natural pastures had a mean of 2.7 acres and a range of 0 - 26 acres (Table 1). Proportionately, the size of land allocated to the different crops in Kilifi and Kwale counties was similar at 13.6, 34.1 and 52.3% and 13.0, 35.1 and 53.2% under napier grass, maize and natural pastures respectively. The area under natural pastures included land under cashew nuts, coconut, mangoes and other trees on the farm. This was an indication that farmers in coastal Kenya gave preference to maize when allocating farm resources as reflected in the results where maize occupied more land than napier grass.

The mean land area under napier grass was 0.7 acres with a range of 0-5 acres. This was an indication that some farmers with dairy cattle did not grow napier grass on their farms. The proportion of land under napier grass (13.7%) was higher than 8.1% and 7.8% reported by [14] for grade cross cattle adopters in Kwale and Kilifi Counties respectively. However, it was less than 0.4 ha per cow recommended by [15] for one dairy cow. It was also lower than National Dairy Development Project (NDDP) recommendation which advocated and emphasized on zero grazing and the growing of at least one acre of Napier grass (*Pennisetum purpureum*) per cow as the primary forage source [3,14,16] reported a decline in area under napier grass between 1993 - 1999 and 2004 - 2009 respectively. With increasing intensification these earlier recommendations may not be appropriate where emphasis has shifted to more production per unit area. This is further aggravated by competition for space with other crops, drought, technical knowhow and availability of clean planting materials were identified by farmers as major constraints responsible for the decline.

Feed Resources Distribution Between Various Seasons

The reported incidences of feed shortages varied from season to season as shown in Table 2. There were no significant differences in feed shortage either by gender or county ($P > 0.05$) (Table 2). Acute shortages were experienced during the months of January to March (season I) with 88.2% of households experiencing feed shortage. At this time farmers had difficulties in meeting the dairy cattle dry matter requirements even after sourcing off-farm. This feed shortage was less pronounced in season III (July to September) where 48.2% of households reported incidences of feed scarcity. In seasons II (12.0% and IV (10.1%) feed shortages were less pronounced. The effects of expected carry-over high biomass production from short rains wet season IV into the long rains dry season I, the effects of long dry season and high animal numbers exacerbated the feed shortages (88.2%). A strategy to mitigate against the seasonal shortages of feed is conservation during the periods of surplus supply.

Table 2: Incidences of feed shortages during various seasons by gender and county.

Seasons of year	Household head		County		
	Female	Male	Kilifi	Kwale	Overall
Season I ¹ (%)	89.6	87.4	85.5	96.2	88.2
Season II ² (%)	11.7	12.3	14.5	4.8	12.0
Season III ³ (%)	49.4	47.5	48.1	48.6	48.2
Season IV ⁴ (%)	11.7	9.2	13.2	1.0	10.1

¹Season I: January - March (long rains dry season); ²Season II: April - June (long rains wet season); ³Season III: July - September (short rains dry season) and ⁴Season IV: October - December (short rains wet season).

Feed Resources Conservation by Gender and County

The proportions of respondents trained on conservation, ever conserved in form of hay and silage varied by household head and county as shown in Table 3. There were no significant differences in feed conservation measures by gender ($P > 0.05$) although

significant differences ($P < 0.05$) existed by county (Table 3). Fodder conservation was not a common practice in this areas as only about 13% of 19.5% households trained had ever conserved forage either in form hay or silage. Of those who had ever conserved, 14.5% had conserved as hay and 8.2% as silage. The results showed low adoption of forage conservation technologies as overall only 13% conserved. Hay conservation was by 4.8% compared to silage by 0.7% of respondents [17], stated that of the two common methods of forage conservation, silage making is technically the most challenging which may explain the lower adoption of the technology. The technical knowhow of the extension officers' aggravated the situation as only 31% were competent on more than one silage making technique [12], thus limiting choices in terms of the silage making technique to adopt by farmers. Lack of technical knowhow by extension agents was also identified as the reason hampering silage making techniques in Thailand by [17].

Table 3: Feed conservation trainings and strategies by gender and county.

Parameters (%)	Household head		County		
	Male	Female	Kilifi	Kwale	Overall
Trained on conservation	21.8	15.6	14.8	33.3	19.5
Proportion ever conserved *	14.2	11.0	14.2	9.5	13.0
Proportion conserved hay *	4.2	5.8	5.8	1.9	4.8
Proportion conserved silage *	0.8	0.6	0.6	1.0	0.7

* Significant ($P < 0.05$) by county.

In Kilifi County, more farmers (14.2%) compared to 9.5% in Kwale County reported to have conserved despite having less farmers trained on conservation. This could be attributed to the difference in land sizes where farmers in Kilifi had smaller land sizes (4.4 acres) compared to 7.7 acres in Kwale County hence a need to conserve (Table 1). As a result, the acreage of forages was inadequate to produce enough for feeding cattle and ensiling/hay making. Despite farmers in the study area having adopted improved fodder production practices, more emphasis in conservation methods is recommended. In addition, seasonal availability of natural forages and profitability of the enterprise may affect adoption of dairy technologies like fodder conservation.

Seasonal Dry Matter Yields and Utilization

The seasonal variations in roughage production and utilization are shown in Table 4. The estimated on-farm feed production ranged from 601.2 - 1,703.9 tonnes DM/season (3,864.7 tonnes DM/year) against estimated cattle requirement of 1,233.8 - 1,261.2 tonnes DM/season (5,003.8 tonnes DM/year) (Table 4). This showed that the amount produced on-farm was inadequate to meet the cattle DM requirements. As a result, 1,553.6 tonnes DM of feed resources was sourced off-farm with the lowest and highest amounts of 114.6 and 579.8 tonnes DM in seasons II and III respectively. The deficit ranged from 311.9 - 561.7 tonnes DM/season. On-farm forage production did not meet the herd requirements except in season II where there was a surplus of 402.3 tonnes DM (23.6%). This represents the amount of feed that can be conserved in season II and used for feeding in other seasons and thus reducing the deficit. With proper management practices, through carry-over of

feed resources between seasons, the overall deficit reduced from 1,381.8 tonnes DM (27.6%) to 979.6 tonnes DM (9.6%).

The total (on-farm and off-farm) available feed ranged from 1,118.5 - 1,818.5 tonnes DM (5,418.3 tonnes DM/year) in season I - IV against potential cattle requirement (d) of 1,233.8 - 1,261.2 tonnes DM (5,003.8 tonnes DM/year) (Table 4). This showed that farmers produced on-farm and sourced off-farm adequate feed to satisfy their cattle minimum DM requirements. However, the amount fed (c) was much less than this and ranged from 1,109.5 - 1,301.6 tonnes DM (4,811.6 tonnes DM/year). While the actual feeding levels had a deficit (192.3 tonnes DM), there was a surplus at current feeding levels of 606.7 tonnes DM. This was an indication that not all feed produced was fed and a substantial amount got spoiled and hence went to waste. At optimum feeding, it was only in season II that there was surplus above animal requirements of 54.1 tonnes DM with season I recording the highest deficit of 124.3 tonnes DM. Season I coincided with the driest months of the year and hence the high deficit. Therefore, some of feed produced on-farm or sourced off-farm went to waste as field observations indicated that farmers utilized roughages without considering the use of any existing storage technologies.

Seasonal Rainfall and On-farm Forage Production Variability

The estimated on-farm forage production followed the rainfall pattern of the area (Figure 1). The pooled seasonal feed resources indicated that the small-scale dairy cattle farmers produced about 77% of the total feed required from within their farms (Table 4). This is in agreement with estimates based on farm size, land allocation and ecological potential that most small-scale farmers in Kenya produce at best 70% of the total feed required from within their farms [16]. However, their ability to sustain this production is season dependent and is compounded by now frequent adverse weather conditions and attempts to bridge the deficit through feed imports from other farms either through purchase or grazing is necessary. Farmers sourced 28.5% (1,543.6 tonnes DM) off-farm. However, some of the feed sourced either on-farm or off-farm went to waste (606.7 tonnes DM/year). The situation is further exacerbated by lack of preparedness of the farmers as exemplified by low numbers engaged in fodder conservation in the study area. In addition, lack of effort to conserve could be explained by farm gate price of milk not being commensurate with the conservation costs.

In the absence of carry-over between seasons, there was excess fodder supply in season II (54.1 tonnes DM) which reduced the amount of forage available for conservation (Table 4). However, assuming appropriate carry over between seasons where excess forage is conserved based on total feed available and cattle requirements $[(a+b)-d]$, the forage produced on-farm and sourced off-farm would be adequate to meet the requirements throughout the year and leave a surplus of 414.5 tonnes DM/year. The amount of feed sourced off-farm would be reduced by 27.6% from 1,573.6 to 1,139.1 tonnes DM/year. As such, farmers should be encouraged to conserve any surplus feed at their disposal for use during times of deficit. As a coping strategy, farmers purchased

forages as an important short and long term strategy to cope with feed shortages in order to increase milk production. The highest amount was sourced in season IV (579.8 tonnes DM) while the lowest in season II (114.6 tonnes DM) to bridge the deficit. The rainy seasons are associated with high biomass production and animals are fed on a variety of feeds, including weeds from the arable land while the planted forages are spared for the dry season. The dry seasons are associated with low biomass production which leads to forage scarcity during the dry months (January to March and July to September). Therefore, the inability of farmers to feed animals adequately throughout the year remains the main constraint for increasing milk production in this region.

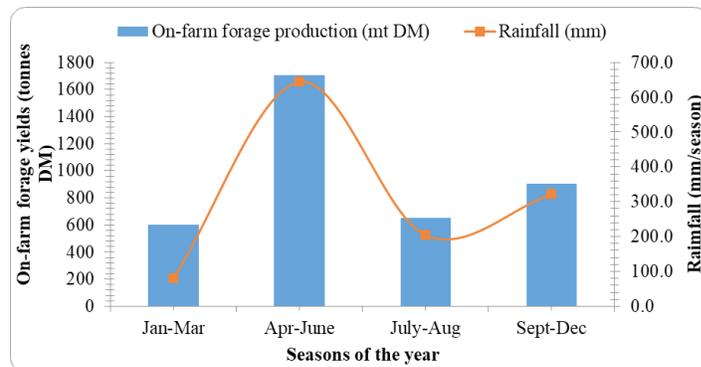
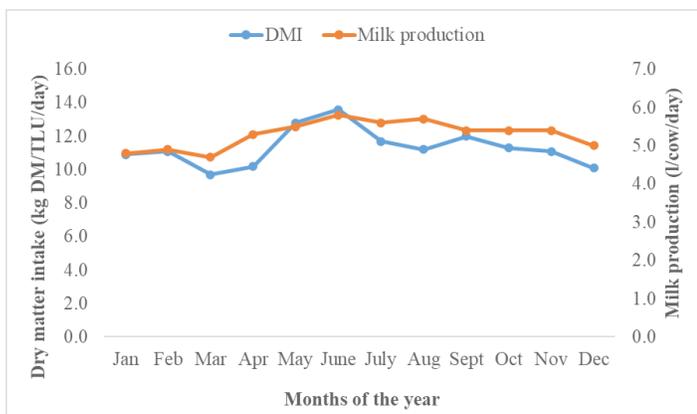


Figure 1: Effects of seasonal rainfall variability on on-farm forage production.

The on-farm feed production deficit of 44.7, 77.3 and 124.3 tonnes DM in seasons I, III and IV was bridged by sourcing off-farm (Table 4). Of the farmers who occasionally had excess fodder (that amounted to 54.1 tonnes DM); it was either left in the fields until the need arose or sold to their neighbours. Others used excess feed for compost making, mulching and bedding for cattle. As observed earlier, maize stover was left in open fields, under trees and in unroofed barns where its quality deteriorated.

Dry Matter Intake (kg/TLU/day) and Milk Production (litres/cow/day)

The relationship between dry matter intake (DMI) and milk production over the months of the year as shown in figure 2. Daily milk yield was used as an indicator of feed quality and quantity offered to the lactating cows. The milk production curve did not follow the DM availability throughout the year. The amount of milk produced remained fairly constant despite fluctuations in dry matter intake. In the wet short rains season (October – December) some cattle were stall fed on lush natural pastures grasses in late December. In addition, crop harvesting of early maturing cereals like sorghum is likely to started and extended to January. Crop residues like maize stover and bean haulms were stored for feeding from January – March. They are inadequate and of low quality and hence responsible for the drop in milk production in February – March every year. Therefore, the variations in milk yield could be attributable to variations in DM availability.



*1 TLU represents a 250 kg mature tropical animal
Figure 2: Relationship between DMI (kg/TLU/day) and milk production (litres/cow/day).

The greatest shortage of feed was experienced from January – March, especially if the short rains failed, when dairy cows were fed on poor quality by-products such as maize stover, mango leaves and dry grass from fallow land. However, in February – March (late dry season) and April (onset of long rains season), feed availability was more acute. Natural pastures not harvested for storage and were fed when overgrown. Despite the increase in DM availability, the crop residues and natural pastures were of low quality hence the reduction in milk production. This was in agreement with [18,19] that during the rainy season pastures are available in higher quantities and show good nutritional quality whereas dry season’s pastures have poor nutritional quality with high fiber and low protein contents, which often results in seasonal weight loss. The resulting nutritional stress leads to decreased productivity expressed through low calving rate, low birth weight, high calf mortality, low weaning weight, reduced mature body size, low growth rate, delayed maturity and more importantly, low milk production [4,20]. Field observations during the study showed that animals preferred feeding on mixtures of weeds (*Commelina sp.*, *Asystasia sp.* etc.) growing naturally in the farm environment to low quality crop residues at the onset of the dry season. As a result, the effects of fodder growth during the long rains season were felt during the following short rains dry season and short rains season.

Dry Matter Intake (kg/TLU/day) and Mean Live Weight Change (x10g/TLU/day)

The relationship between dry matter intake (DMI) and mean live weight change (MLWC) varied as shown in figure 3. Except during the long rainy dry season, the DM availability was closely related with MLWC. The animals lost weight during the dry season as the feed available was of low quality. In most farms, even during the rainy season the amount of fodder available for livestock was inadequate in both quality and quantity. A short wet season is often associated with a long dry season during which the decline in feed quality may cause weight loss. This situation is acute during the dry season when animals are underfed and often malnourished [21,22]. During this season browse tree legumes like *L. leucocephala* should be exploited due to both availability

and high supplemental value, especially protein. Due to their deep rooted nature of these browse species, they are able to tap water and nutrient resources deep in the soil profile and remain available even during the dry seasons.

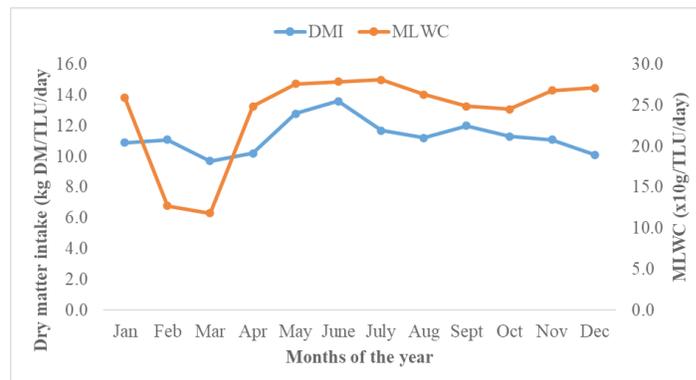


Figure 3: Relationship between DMI (kg/TLU/day) and MLWC (x10g/TLU/day).

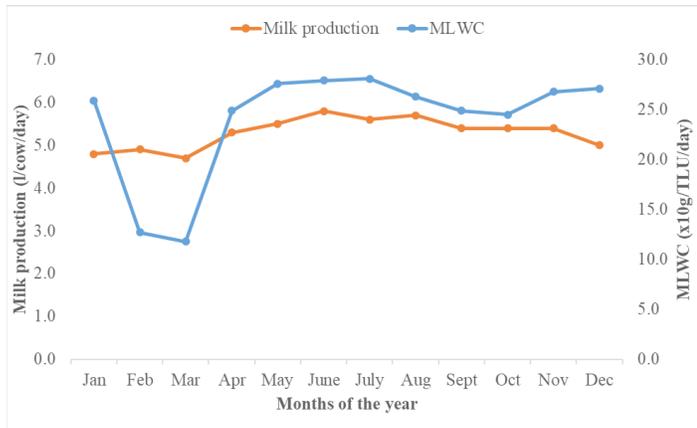
In the study area, 55.2% (Table 4) of the available roughages consisted of natural pasture grasses, characterized by low CP of 84.1 - 97.1 g/kg DM which would adversely affect rumen microbial activity [23]. During the long dry season, quality of much of the feed was so poor that intake was below 11.7 kg DM/day required for maintenance resulting in animal weight loss. Napier grass supplied 15.1% of the feed resources and had a CP of 86.4 g/kg DM. In small-scale farms in Kenya, feeding of napier grass was associated with low live weight gains of about 0.21 kg/day on young stock fed on napier grass of CP less than 80 g/kg DM [24].

Milk production and MLWC had similar patterns except from July - September where the former increased while the latter decreased (Figure 3). In the study area, over 80% of the feed resources consisted of maize stover, napier grass and natural pastures, characterized by low quality (CP 72.2 - 97.1 g/kg DM). Natural pastures had 84.1 g/kg DM CP and provided 35.7% of the feed resources requirements underlying the inability of farmers to feed animals adequately with high quality feeds throughout the year. Animal productivity such as milk production and live weight change (LWC) is a function of feed availability and intake, nutrient concentration, digestibility and metabolic efficiency [25].

Milk Production and Mean Liveweight Changes

The relationship between milk production and mean liveweight changes in the study area are shown in figure 4. Milk production and MLWC had similar patterns except from - March where the despite the decrease in the latter, it remained fairly constant. During the months of February and March there was noticeable decline in MLWC which coincided with periods of highest feed deficit of -124.3 tonnes DM (Table 4). Animal productivity such as milk production and live weight change (LWC) are a function of feed availability and intake, nutrient concentration, digestibility and metabolic efficiency [25]. In the study area, over 80% of the feed resources consisted of maize stover, napier grass and natural

pastures, characterized by low crude protein and high crude fibre levels. The bulk of feed resources was from maize stover, napier grass and natural pastures underlying the inability of farmers to feed animals adequately with high quality feeds throughout the year.



*1 TLU represents a 250 kg mature tropical animal

Figure 4: Relationship between milk production and mean liveweight changes.

Table 4: Estimated seasonal variations in roughage dry matter yields and utilization.

Parameters	Season I ^a	Season II ^b	Season III ^c	Season IV ^d	Total
Estimated on-farm forage production (tonnes DM) (a) ¹	601.2	1,703.9	654.9	904.7	3,864.7
Estimated amount sourced off-farm (tonnes DM) (b) ¹	517.3	114.6	579.8	341.9	1,553.6
Total feed available (tonnes DM) (a+b) ¹	1,118.5	1,818.5	1,234.7	1,246.6	5,418.3
Estimated amount of forage fed (tonnes DM) (c) ¹	1,109.5	1,301.6	1,216.6	1,183.9	4,811.6
Estimated cattle forage requirement (tonnes DM) (d) ²	1,233.8	1,247.5	1,261.2	1,261.2	5,003.8
On-farm production feed deficit/surplus (tonnes DM) (a-c)	-508.3	402.3	-561.7	-311.9	-946.9
Farm feed surplus (tonnes DM) [(a+b)-c]	9.0	516.9	18.1	30.0	606.7
Potential feed deficit/surplus (tonnes DM) [(a+b)-d]	-115.3	571.0	-26.5	-14.6	414.5
Actual feeding deficit/surplus (tonnes DM) (c-d)	-124.3	54.1	-44.7	-44.7	-192.3

¹Estimated from field measurements; ²Estimated cattle forage requirement was estimated by adding 25% for feed refused, storage losses and/or harvesting losses in the field [18]. Negative value indicates a deficit.

^a Season I: January - March (dry); ^b Season II: April - June (wet); ^c Season III: July - September (dry) and ^d Season IV: October - December (wet).

Pooled and Optimum Feed Use

The effect of pooled feed use on herd size, MLWC, milking animals, MMP and MDMI are shown in Table 5. Carry-over feeds refer to collecting and temporary storing of feed to allow synchronization of feed supply to animals' feed demand for an optimum feeding regime [25]. It is implicitly assumed that the feeds are properly stored to maintain their quality throughout the feeding period and that labour availability is sufficient to collect, store and chop mixtures of feeds for livestock. The feed required depends on its quantity and quality and the weight, physiological stage of growth, lactation stage and number of cattle.

Except in the herd size, the optimum feed use model results closely resembled the actual performance when feeds were pooled in the study area (Table 5). When all feed sourced on-farm and off-farm was considered per season at assumed constant TLU of 1,462, the MLWC ranged from 168 - 268 g/TLU/day for the whole herd, MMP ranged from 4.7 - 5.6 litres/cow/day and MDMI ranged from 10.6 - 12.2 kg/TLU/day. This was within MDMI range of 8.8 and 9.6 kg/head/day from Napier grass (*Pennisetum purpureum*) which is the main fodder source, in the coastal region [16]. However, it compares poorly with the estimated daily DM requirement of the common dairy breeds of 14 - 17 kg/head/day [16], suggesting a large feed deficit.

Feed deficit occurred in seasons I, II and III as the MDMI of 11.0, 11.3 and 10.5 kg/TLU/day which was below 11.7 kg/TLU/day required to meet the cattle maintenance, production and reproduction requirements (Table 5). This was an indication that at the current feeding levels, the animals in the study area were fed below their requirements as was reflected in the feed deficit in seasons I, II and III respectively, hence low milk production and MLWCs. As such, in coastal lowlands where most feeds are of low quality, optimum benefits from livestock could be obtained by selective utilization of quality feeds, through proper storage and carry-over systems. In addition, with increasing intensification of farming through zero-grazing, development and research on strategies to diversify feed resources on farms has the potential to enhance milk production.

In the model, available feed resources sourced off-farm and produced on-farm were characterized according to DM on a seasonal basis (Table 5). At optimum use of feed (100% use of DM produced on-farm and sourced off-farm) per season, the herd size ranged from 1,055 - 1,222 TLU at 11.7 kg/TLU/day of feed in seasons I and IV respectively. Mean live weight changes (MLWC) and mean milk production increased with decreasing herd size. Milk production per cow per day increased and ranged from 5.3 - 5.8 litres with reduced herd size probably because of low quality of feeds. The optimum feed use model predicted mean live weight changes (MLWC) with carry-over of feed resources for the optimum number of TLU at 187 - 278 g/TLU/day. Even in times of excess feed supply in season IV, such predicted weights are difficult to achieve and could be attributed to low quality of feed. Actual herd size at all feeds used was 1,462 TLU which was lower than the predicted herd size that could be supported when all

feeds were pooled in all seasons. A similar trend was observed in the number of milking animals. This clearly indicated that except for season IV, the DMI was inadequate to support the 1,462 TLU in farms.

Table 5: Effect of pooled and optimum feed use on some production parameters.

Parameters	Seasons	HS (TLU)	MLWC (g/TLU / day)	Milking animals (TLU)	MMP (litres/ cow/day)	MDMI (kg/ TLU/day)
All feeds used	Season I	1,462	264	595	5.6	11.3
	Season II	1,462	261	610	5.2	11.0
	Season III	1,462	168	549	4.7	10.6
	Season IV	1,462	268	488	5.5	12.2
Optimum use (100% DM used)	Season I	1,131	274	460	5.8	11.7
	Season II	1,100	278	459	5.6	11.7
	Season III	1,055	187	396	5.3	11.7
	Season IV	1,222	257	408	5.3	11.7

HS - herd size; TLU - Tropical Livestock Unit (1 TLU represents a 250 kg mature tropical animal); MLWC - mean live weight change; MMP - mean milk production; MDMI - mean dry matter intake; **Season I:** July - September; **Season II:** October - December; **Season III:** January - March and **Season IV:** April - June.

In sub-Saharan Africa, the demand for milk and meat is expected to grow by 3.9 percent and 3.2 percent per annum between 1997 and 2020 [27]. These trends in food demand have important implications for natural resources that provide essential support to life and economic processes. The increased demand can only be achieved by a combination of expansion in animal numbers, increased production per animal and agricultural crop [28]. The projected increase in production cannot be attained through feeding more of the biomass, but by providing good quality feeds. The suggestion by [8] that livestock production in developing countries in the tropics could be considerably increased by using all feed resources is not supported by the results of this study. However, for some farmers, reduction of herd size may conflict with other functions of livestock such as savings and capital asset accumulation. In the study area, keeping a large number of animals is associated with high risks of losses due to deaths during periods of feed shortages and farmers did not adjust their herd size according to fluctuations in feed supply.

Short Term Strategies to Cope with Feed Shortages

Short term strategies employed by farmers to cope with feed shortages are shown in Table 6. The short term strategies used ranged from feeding less to animals to renting grazing pastures (Table 6). During the dry seasons, the forages were inadequate and farmers and labourers had to walk for long distances in search of forages whether for grazing or stall feeding. As a result, 31.6% of farmers opted for feeding less to animals as the most suitable coping strategy. However, feeding less forage amounts to animals led to decreased milk production and hence reduced income. In the past, neighbours used to allow free harvesting or grazing without

payment, but 3.7% paid for grazing pastures either in cash or in kind as milk or manure. Forage was purchased from neighbours who did not keep cattle as indicated by 16% of respondents.

Table 6: Short term strategies to cope with feed shortages.

Strategy	1 st choice feeding strategy	2 nd choice feeding strategy
Feed less to animals	31.6	8.8
Feed tree leaves	30.2	33.2
Reduce herd size	18.2	12.3
Purchase more fodder	16.3	38.8
Rent grazing pastures	3.7	7.0

Long Term Strategies to Increase Milk Production

Long term strategies employed by farmers to cope with feed shortages are shown in Table 7. The long term feeding strategies suggested to increase milk production were more own on-farm feed production (44.6%) and purchase of more feed off-farm (14.7%) (Table 7). As human population size increases, land availability will decrease and intensification of land use as well as greater adoption of high yielding fodder crops including napier grass for production of more feed on-farm will probably be the only viable option to sustain and improve dairy production. Labour requirements for dairy cattle related activities would then increase. In allocating labour for the various farm activities priority was given to food crops production and this was high during the planting and weeding periods of the wet season. At such times management of napier grass (weeding and return of slurry) was not done as recommended. As a result, the productivity of napier grass was low and some stools died during the dry seasons further reducing fodder production. Demand for labour on mixed farms was high throughout the year, but increased in the dry period when forage was scarce as farmers had to walk for longer distances in search of forages.

Table 7: Long term strategies to increase milk production.

Long term strategies (%)	County		Household head		Overall
	Kilifi	Kwale	Male	Female	
Produce more feed on-farm	55.2	41.0	39.8	52.6	44.6
Purchase more feed off-farm	0	19.7	15.3	13.6	14.7
No strategy employed	44.8	39.3	44.9	33.8	40.7

Conclusion

Cattle were fed predominantly on naturally occurring forages (e.g. grasses and leaves), crop residues and agriculture by-products and in some areas on planted forages (e.g. Napier grass, tree legumes and other legumes). These factors made it difficult to formulate feeding strategy based on stipulated feeding standards. Natural pastures were the most readily available feed resource at 55.2%. Despite feed management strategies aimed at reducing the seasonal variations in the feed quality, it still remains a major constraint. Feed supply during the dry seasons, which in the study area is most severe in the periods from January to mid-March and August to mid-October, constitutes an important limitation to animal production.

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