BIO-ECONOMIC PERFORMANCE OF GRADE DAIRY CATTLE IN MIXED SMALL SCALE FARMING SYSTEMS OF VIHIGA, KENYA

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university

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DEDICATION

This thesis is entirely dedicated:

First to;

My cherished wife Lynet, sons – Silas, Paul and Randy Raphael for their encouragement, support and prayers: They made me understand in depth Psalm 91 and 121 and my strength was renewed always.

Second to;

My late father Silas Gidali Mudavadi (1938–1993) who in March 1993 told me that I was destined to be a scientist. I now see it becoming real in my life and I am determined to pursue further.

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Despite the enormous sources of assistance and varied opinions shared with different persons from different institutions, the views expressed in this thesis do not necessarily reflect those of any of the informants nor did the institutions that they were/are affiliate with. While every effort has been made to maintain an accurate presentation of the subject matter of this thesis, the author is solely responsible for any remaining error(s).

EBENEZER

"Thus for the LORD GOD has helped me this far, and I give Him all the glory and honour."

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ABSTRACT

This study examined the influence of existing grade dairy cattle production factors and systems on bio-economic performance of grade dairy cattle in the mixed small scale farming systems of Vihiga, Kenya. Whilst there is an increasing interest in smallholder grade dairy cattle production, at the same time information on bio-economic performance under the different grade dairy cattle production systems from the producers' perspective is scanty. Detailed data on the farm system, resources and bio-economic performance parameters was collected using a pre-tested structured questionnaire at the household level from a purposive sample of 236 grade dairy cattle owning households in Vihiga between April-August 2005. The data was entered in MS Excel spreadsheet and subjected to SPSS (Version 10.0) for ANOVA, descriptive statistics and frequencies based on the existing grade dairy cattle production systems.

The Dairy Simulation Model *v3.2*, which is part of the Livestock Feeding Simulation "LIFE-SIM" Models group, gross margin and benefit-cost analysis were used to quantify the influence of existing grade dairy cattle production factors and systems on bio-economic performance. Land sizes in Vihiga were small (2.27 acres), hence grade dairy cattle production systems were mainly intensive (stall feeding only and mainly stall feeding with some grazing). The most important crops to the grade dairy cattle owning households were maize, beans, bananas and tea as identified through farmer perception and ranking. Maize and beans remains the sole most important combination (0.76 acres) and tea the main cash crop (0.58 acres). Napier grass was the main basal feed resource for grade dairy cattle (0.54 acres).

The major objectives in farming and dairying were food supply and milk for home consumption respectively. Grade dairy cattle had low milk yield/cow/day (5.49 litres) with long calving intervals (18.66 months) and age at first calving (31.11 months). Grade dairy cattle herd size was significantly influenced ($P<0.05$) by the production system and comprised mainly Ayrshire cross (33.1%) and Holstein-Friesian cross (30.5%). Simulation analysis showed that

feeding strategies for grade dairy cattle were sub-optimal, reflected in low actual and potential milk yields per cow per day and per 305 lactation periods. Further, the costs of milk production, gross margins from milk and manure production were higher in intensive production systems as opposed to the extensive production systems.

Grade dairy cattle production systems significantly influenced ($P<0.05$) total expenditures on inputs and total output value from the grade dairy cattle sub system and tea for the crops sub system. On the contrary, grade dairy cattle breed types had no substantial influence ($P>0.05$) on total expenditures on inputs and total output value from both the crops and grade dairy cattle sub systems. Further, both breed types and production systems had little influence ($P>0.05$) on gross margins of the two sub systems. The cash output - input ratios for the two sub systems were similar and above 2.0.

Also from simulation analysis, Mainly stall feeding with some grazing production system had the highest economic returns, though income to cost ratios in the four grade dairy cattle production systems were 2.0 and above implying a solid base for profitable dairy production in Vihiga. The results further showed that there was little interaction between the grade dairy cattle production systems and breed types and hence the need to identify optimal breed types for each grade dairy cattle production system. Generally grade dairy cattle contributed 70% of the total farm incomes of grade dairy cattle owning households, while crops contributed 30% highlighting their importance in the mixed small scale farming systems.

Chapter 1

1.0 INTRODUCTION

Dairying in the mixed small scale farming systems is viewed by both farmers and development agencies as a promising avenue for rural poverty alleviation, asset building and the efficient utilization of intensified land use (Rijk de Jong, 1996; Nicholson, et al., 2001; Bebe et al., 2002). It is therefore expected that the number of small scale dairy farmers will continue to increase in the foreseeable future (Delgado, et al., 2001). This increasing number of small scale farmers, that are mostly subsistence due to limitations in land and capital, has stimulated an increased interest in the role of dairy cattle in the mixed farming systems around the developing world (McDowell and Hilderbrand, 1980; Skunmun and Chantalakhana, 1999). The questions being asked, therefore, are whether the dairy cattle represent a burden on the system, consuming resources that could be put to more productive use or whether the small scale farmer utilizes the animals to improve and stabilize the complex social and agricultural systems.

Dairy cattle production systems in Western Kenya, and Kenya as a whole, have been studied extensively, and many negative and positive aspects have been reported separately (Stotz, 1979; Baptist, 1990; Peeler and Omore, 1997; Omore et al., 1999; De leeuw, 1999; Wakhungu, 2000; Bebe, 2003; Waithaka et al., 2002). However, an integrated study dealing with the various facets (components) of productivity is lacking. For instance, although economic and nutritional aspects have been extensively reported, there are no studies dealing with the question of whether activities and enterprise choices in the dairy production system and mixed farming systems in general, contribute to increased productivity and production efficiency. Development of appropriate technologies to the assist smallholder dairy producers requires a clear understanding of the dairy systems of the target farmers (Waithaka, et al., 2002).

Dairy cattle production in the mixed small scale farming systems of Vihiga, ranks second after maize in contributing to household incomes and food security (Wangia, 1998). Cultural laws on inheritance and government policies on sub-division of land, compounded by increase in human population have reduced land sizes in Vihiga, while demand for dairy products and incomes has increased. Although smallholder dairy development projects have been in progress for many years in Western Kenya, Vihiga continues to have milk deficit characterized by highest household consumption and least sales as shown by Waithaka, et al., (2002). Subsistence production is predominant with less market orientation and specialization. There is still high preference for zebu cattle though the demand for dairy products is quite high and the agro climatic potential is extremely favourable for grade dairy cattle production. On average, productivity of grade dairy cattle in the mixed small scale farming systems of Vihiga is low and exploitation of their potentially high production is limited by lack of knowledge of the inter-relationships between the various components of the production systems.

Recent studies in Vihiga (Waithaka, et al., 2002) indicate that grade dairy cattle bio-economic performance (productivity) indicators are lower than are realized from similar agro-ecologies in the Kenyan highlands (Staal, et al., 1998; Bebe, 2003). To understand bio-economic performance of grade dairy cattle in Vihiga, one has to quantify their contribution to the small-scale mixed farming systems. It is against this background that the **purpose** of this study was, therefore, to identify, quantify and analyze the influence of existing grade dairy cattle production factors and production systems on bio-economic performance of the cattle in the mixed small-scale farming systems of Vihiga, Kenya. **The specific objectives were:**

(a) Characterize grade dairy cattle owning households under four grade dairy cattle production systems within the mixed small-scale farming systems of Vihiga.

(b) Model the influence of existing feeding strategies on performance of grade dairy cattle under four grade dairy cattle production systems in Vihiga.

(c) Analyze expenditure on inputs (costs) and output values from grade dairy cattle and crops sub systems within the mixed small scale farming systems of Vihiga.

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2.0 LITERATURE REVIEW

2.1 Dairy Production in Developing Countries

Developing countries have nearly two thirds of the World's livestock but produce only a quarter to a third of the world's meat and a fifth of the world's milk (FAO, 2004). The low output in developing regions is due to both low off-take rates and low yield per animal. Approximately 51% of the world's dairy cattle are found in developing countries. These dairy cattle contribute approximately 21% of global milk production (ILRI, 1999; Falvey, 1999). Dairy production in developing countries is important because it provides milk for home consumption, employment and generates regular financial returns (Walshe, et al., 1991; Wilson, 1994; Mohamed-Saleem, 1995). There is a high and increasing demand for dairy and dairy products in developing countries due to the increase in human population (Delgado, 2001). This increased demand, coupled with the need to improve the incomes of the rural population as well as the increasing pressure on land (Mohamed-Salem, 1995) has led to intensification of dairy production, resulting in the smallholder dairy production systems integrated with cropping observed in India (Payne, 1990), Tanzania (Msanga, et al., 1998), Kenya (Peeler and Omore, 1997) and Indonesia (Trisunuwati, et al., 1991).

2.2 Dairy Production in Kenya

Kenya has one of the most successful dairy industries in sub-Saharan Africa based on some three (3) million cattle mostly high grade *Bos Taurus* dairy breeds and a relatively advanced milk marketing infrastructure. The main breeds for dairy production are Friesian, Guernsey, Ayrshire, Jersey and their crosses with the local East African Zebu (EAZ). The EAZ population is estimated at about 10 million, and produce relatively small amounts of milk per cow, little of which is marketed. Kenya's dairy cattle population, estimated at three (3) million (Peeler and

Omore, 1997), make up at least 70% of the total in eastern and southern Africa, a major factor contributing to the per capita milk availability of about 106 kg in Kenya (Table 2.1) compared to only 20-40 kg milk per capita in most neighbouring countries. In contrast to current trends of increasingly large and specialized dairy production units in most industrialized countries, about 80% or 2.5 million of the dairy cattle in Kenya are on smallholder mixed crop-livestock farms typically with 1-4 cattle on approximately 1-2 ha of land.

Most dairy production occurs in fertile highland areas supporting large human populations close to major urban centres where demand for milk is high. About 60% of total milk is produced from less than 10% of the country's landmass in the central highlands (Reynolds et al., 1996) where 60% of exotic and crossbred dairy cattle are found and intensification of agricultural production has been a response to human population pressure on land. Approximately 80% of the milk production in Kenya is from smallholder farms (Peeler and Omore, 1997) concentrated in high and medium potential areas of Central, Rift Valley and Western Provinces and also the coastal lowlands. Over two-thirds of households keep dairy cattle in most of these areas (Staal, et al., 1998).

Most consumers prefer to buy raw unprocessed milk (Omore, et al., 1999). This preference has become increasingly apparent in urban centres where processed milk sales were dominant until market liberalization in the early 1980's (Bebe, 2003). Besides dairy cattle, mixed small scale farmers keep other livestock (mostly chickens, sheep and goats), grow crops for sale (for example tea, coffee, sugar cane) and crops for subsistence (for example maize, beans, bananas, vegetables). Horticultural crops grown for sale are becoming increasingly important. The interactions and complementarities between crop and livestock enterprises improve farm efficiency through nutrient cycling. In a few instances, the value of manure is seen by farmers to be the same as, or supersedes, the value of milk especially

Table 2.1. Cattle population and annual milk production and availability per capita in Kenya

Indigenous cattle		Dairy cattle		Human population	Milk per capita
Population (‘000)	Milk prod. (‘000 MT)	Population (‘000)	Milk prod. (‘000 MT)	(‘000)	
9,831	574	3,045	2,501	29,000	106

Source: MoALD Annual reports and Peeler and Omore (1997)

Key: MT = Metric Tonnes

where milk markets are not reliable (Lekasi, 1998). Most smallholders do not maintain farm records. Labour resources consist of available family labour, hired casual and/or permanent labour. Dairying is often cited as the most important source of income throughout the year. The increase in smallholder dairy production in Kenya has been achieved primarily through increase in cattle numbers whilst the productivity of the animals remains very low (Stotz, 1979). This low productivity has increased the gap between demand and supply of nutrients from dairy products. For instance, dairy products supply less than 2% of calories and about 4% of the protein in the average human diet (Michael et al., 1991). It is worth noting that the aggregate demand of dairy products in Kenya grew steadily in the 1960's through the early 1980's due to the rising human population, urbanization and increase in per capita income (Walshe, et al., 1991; Delgado, et al., 1999).

Despite the substantial amount of investment made in dairy development projects throughout Kenya, the impact has been small. Dairy cattle owners have not widely adopted the technology packages developed through the projects which are explained by several reasons including cultural and socio-economic factors (Waithaka, et al., 2001).

According to the World Bank (1985), the reasons for the failures of dairy cattle development projects could be due to inappropriate project design arising from lack of understanding of dairy production systems, as well as lack appropriate technologies. This identifies the need and necessity to improve our knowledge of the dairy production systems within the mixed small scale farming systems before any interventions are contemplated. Thus, it is important to analyze the rationale for integrating dairy production enterprises into the mixed farming systems, identify the factors influencing productivity and also identify the conditions needed for improvement.

2.3 Dairy production in mixed small scale farming systems

The highlands are the most intensively cultivated areas and support the highest population densities and livestock stocking rates of any agro-ecological zone in Kenya. Population pressure hence reduction in land sizes has triggered the evolution and adoption of mixed crop-livestock production, replacing the former extensive grazing and bush fallow systems. Mixed farming, defined by Janhke (1982) as the "intensification of the output function of livestock within the farm system parallel to the development of the farm input function (work and manure) and the increased integration of livestock for the benefit of soil fertility and overall farm productivity", is not a new phenomenon to sub-Saharan Africa. It is an important attribute of smallholder dairy farming and is highly associated with sustainability of the farming systems. Crop residues are fed to livestock while manure from the livestock is supplied to the crops, contributing to nutrient cycling and replenishment of soil fertility that would otherwise be depleted.

Studies carried out so far in smallholder households in Kenya, in the face of the continuing pressure on land and the resultant intensification of land use systems, have shown that many farm households would be unable to sustain their families without the benefits accruing from dairying and its interaction with crop production (Staal, et al., 1998; Waithaka, et al., 2002). In this case, integration of crops and dairying, particularly when supported by a market infrastructure continues to provide smallholder farmers with an opportunity to reduce the risks inherent in production from a single crop or livestock enterprise, a strategy crucial to food security and poverty alleviation.

Although the degree of crop-dairy cattle integration in mixed small scale farming systems may be less than optimal, integrated crop-dairy cattle production has become an important feature in highland farming systems (Jahnke, 1982). Mixed small scale farmers usually take a broad perspective to dairy production (Mclntyre, et al., 1992). Dairying is practiced to produce milk for feeding the family and for sale, to produce manure to support crop production and dairy animals are a form of insurance and finance emergency cash needs and for social status (Udo and Cornelissen, 1998).

2.4 Factors influencing bio-economic performance of grade dairy cattle in mixed small scale farming systems

2.4.1 Land

Availability of land has remained the major obstacle limiting improved dairy production on smallholder farms in Kenya. Due to population pressure, household farm sizes are small. The average land size per household in Vihiga district, for example, is 1.3 acres or 0.5ha (Salasya, 2005). The size of land holding per household varies greatly, and is generally seen as one of the main determinants of intensification level (Staal, et al., 2001). Land scarcity has direct implications on the quantity and quality of feed or level of feed investment and stocking rates. In areas where land sizes are small and land is thus a primary constraint to production, farmers have an incentive to intensify and mostly adopt intensive systems of keeping cattle, especially 'stall feeding'.

2.4.2 Labour

Labour on the smallholder mixed farms in the high potential areas of Kenya is required to cut and carry forage to stall fed dairy cattle and to carry out routine management practices (Staal, et al., 2001; Waithaka, et al., 2002). Feeding dairy cattle is a major daily occupation throughout the year and in most cases is provided by the family or hired labourers. Casual labour is mainly employed in crop related activities (Wangia, 1998; Staal, et al., 2001). The demand for labour is high during fodder planting and weeding, which also coincide with peak labour requirements for cash or food crops; then the farmer or hired labourer have limited time to cut road side grass or napier grass from distant plots, so alternative forage available on farm for example stored crop residues, is fed.

2.4.3 Feeds and feeding systems

Many mixed small scale grade dairy cattle farmers rely largely on feeds from their own fields or cut from communal areas such as roadsides. Inadequate feed supply has been cited by farmers as one of the constraints to dairy production and may explain low milk yields from grade dairy animals with higher genetic potential (Staal, et al., 1997, 1998; Omore, et al., 1999; Waithaka, et al., 2000, 2002). The preferred fodder crop planted by smallholder farmers in Kenya is napier grass (*Pennisetum purpureum*), because of its high dry matter (DM) yield (Kariuki, 1998). Due to limitations of available land, most smallholder farmers on average allocate land to napier grass which is lower than the recommended 0.40ha per cow and heifer (NDDP, 1989).

Extensive use of cut napier grass as feed in stall fed dairy cows has been reported in Central Kenya (Staal, et al., 1997; Kariuki, 1998). Due to the small land sizes allocated to napier grass, cut grass from roadsides play an important role as a feed resource. Leguminous shrubs like *Leucaena leucocephala* or other legumes like *Desmodium spp* have not been adequately adopted by farmers in these intensively cultivated areas (Staal, et al., 1997; Waithaka, et al., 2000) so their contribution to on-farm feed resource is not significant. Maize is the major food crop grown by smallholder farmers in the Kenya highlands. Therefore maize stover is the main crop residue used as feed during times of shortage of napier grass (Staal, et al., 1998; Waithaka, et al., 2000). Ǿrskov and Ibrahim, (1991) and Ǿrskov, (1999) have also reported use of crop by products such as rice straw by smallholder farmers in Asia.

The average land allocated to maize production on mixed small scale farms in Western Kenya is 0.48 to 1.72 acres (Wangia, 1998; Waithaka, et al., 2002; Salasya, 2005). Due to low fertilizer usage, yields of maize and stover are low on most farms (Waithaka, et al., 2002). Other crop-residues arising from mixed farming activities include banana leaves, banana pseudo-stems, sweet potato vines, maize thinning and vegetable waste. Smallholder farmers also commonly use commercial concentrates. High cost of concentrate supplements has been mentioned by farmers as a constraint to dairy production (Staal, et al., 1998; Waithaka, et al., 2000). As a consequence of seasonality of rainfall and fodder supply by napier grass, seasonal feed shortages are often reported on mixed small scale farms. Napier grass is therefore the main feed resource during the wet season, while in the dry season, crop residues mainly maize stover, banana pseudo stems and agro-industrial by products become important feed resources. Farmers may also buy fodder during these times of feed shortages.

2.4.4 Grade dairy cattle production systems and breed types

Waithaka, et al. (2002) characterized grade dairy cattle production systems in Western Kenya as grazing only (free grazing), mainly grazing with some stall-feeding, mainly stall-feeding with some grazing and stall-feeding only (zero-grazing) based on the level of intensification and feeding systems. Grade dairy cattle genotypes were classed as: cross breeds (50% or less *Bos Taurus*), or high-grade dairy (more than 50% *Bos Taurus*). The *Bos Taurus* breeds in the cross breeds were: Holstein-Friesian, Ayrshire, Guernsey and Jersey. Production systems in dairy farming in the Kenya highlands are variable; each responding to particular marketing and environmental conditions (Staal, et al., 2001). Long-term competitiveness of these systems changes over time, depending on land values, market and institutional infrastructure. There is still widespread practice of traditional production systems based on indigenous cattle breeds with attendant low productivity among smallholder farmers which has been attributed to many factors. Among these are inadequate communication, lack of required inputs and/or insufficient interest of the farmer (Pagot, 1976). Lack of smallholder adoption of “improved dairy cattle production practices" is thought to result from inappropriate production alternatives being offered (Waithaka, et al., 2002, Bebe, 2003).

In Western Kenya about 76% of crossbred and purebred dairy cattle are found in the small scale intensive production (zero-grazing and semi-zero grazing) systems in peri-urban herds. The majority are stall fed on planted fodder/forage or harvested natural pasture and crop by-products (Mudavadi, et al., 2001, Waithaka, et al., 2002). The remainders are grazed on natural pastures often supplemented with crop residues, some fodder and/or concentrate. There is significant urban dairy cattle production from small herds, often owned by civil servants, based on purchased forage or public grazing land. The greatest hardship faced by these production systems is the rapidly growing human population against low producing cattle genotypes (Staal, et al., 1998). Land holdings continue to diminish due to increasing human population and affects the area available for grazing and/or growing fodder crops. This, coupled with increasing market availability for dairy products in urban centres and improving infrastructure (De leeuw, et al., 1999), is currently stimulating rapid adoption of intensive smallholder dairy farming, that is likely to change the set up of the semi-intensive systems.

Productivity from the extensive and semi-intensive production systems appears to a factor of distance from the major urban consumption centres, and the adequacy or otherwise of the market infrastructure to link them. Large price differentials between rural and urban centre are indicators of relative deficit and surplus areas. The potential to increase milk production from the different dairy cattle production systems depend on the cost of collection and transport, particularly where distance-sensitive informal (raw milk) markets predominate. In turn unit cost of supply services such as input supply, animal health services and milk marketing decrease as production intensifies (Walshe, et al., 1991). Consequently, dairy cattle production is highly varied in structure of production and achievement of biological potential.

2.4.5 Dairy cattle reproductive management

Calving intervals averaging 600 days are common (Odima, et al., 1994; Staal, et al., 1998; Waithaka, et al., 2002) on smallholder farms in the Kenya highlands as indicated in Table 2.2. The prolonged calving intervals are due not to disease but due to the fact that many farmers only consider breeding cows after they have been milked for at least 200 days (Odima, et al., 1994). The decisions by farmers to voluntarily lengthen calving intervals and the low milk yields are associated and need to be resolved together (Tanner, et al., 1998). Smallholders use artificial insemination (AI) or rely on communal bulls where private or public AI services cannot be accessed easily. Very few farmers raise bulls for breeding on their own farms because they prefer to use their limited fodder supplies for cows and female replacements. A shortage of own-produced replacements due to low calf survival and heifer and cow mortalities implies that many farmers obtain replacements from large scale farms (Bebe, 2003).

2.4.6 Dairy cattle health constraints

Infectious and vector-borne diseases are important on mixed small scale farms but often their incidence decreases with increasing sub division of land and stall feeding (Omore, 1996b). Tick borne diseases are a major cause of morbidity and mortality in extensive farming systems, warmer climates and lower altitudes (Maloo, et al., 1994), but are of lower importance in cooler areas at higher altitudes, especially if animals are stall fed (Deem et al., 1993; Omore, et al., 1996a). Tick borne diseases are controlled through hand spraying of accaricides, hand picking and rotational grazing. Cattle are predisposed to lameness and foot lesions due to confinement in the zero grazing housing systems. Gitau, (1995) found a high incidence of foot lesions, but the incidence of lameness was relatively uncommon (1.46% per month or 17.5% per year). He concluded that though lameness was currently not a serious constraint to production in these farms, if cows are pushed to higher levels of production, these lesions may become important in constraining milk production.

Table 2.2. Indices for production variables of animals on smallholder dairy farms in Kenya

Variable	**N**	**Range**	**Median**	**Mean** ± **s.e**
Milk yield (kg/day)	1734	0.3-25	5	5.8 ± 0.08
Months of lactation	1670	1-39	8	9.9 ± 0.17
Age at 1st calving (yrs)	28	2.2-5.0	3.4	3.4 ± 0.15
Calving interval (days)	176	308-1256	620	633
Calf growth rate (kg/day)				
Males	181	-0.4 – 0.9	0.20	0.22 ± 0.01
Females	180	-0.2 – 0.8	0.28	0.26 ± 0.01

Sources: Odima et al., (1994); Omore et al., (1996a)

2.4.7 Calf rearing

Low calf growth rate (mean weight gain only 0.24 kg/day, up to 5 months of age) and high annual calf (up to one year of life) morbidity and mortality of 27% and 22% respectively were recorded in a study in Western Kenya (Waithaka, et al., 2002). Diarrhoea was found to be the most important cause of calf morbidity and mortality. The poor growth rates result in late age at first calving. Besides high reproductive wastage due to high calf mortality, the farmers also lack the ability to select female replacements. Additionally due to the low calf survival rates, most female calves that survive are retained, irrespective of their potential. The low milk production by their dams is also probably an important constraint to optimal calf growth. Farmers reported bucket-feeding about 3kg of milk up to three months of age. Many farmers slaughter or in other ways dispose off their male calves.

2.4.8 Milk marketing and input services

The marketing of milk has increasingly become decentralized, with increasing private sector participation since market liberalization in 1992 (Dairy Development Policy, 1993). Most milk from smallholders is sold unprocessed to neighbours or in local village markets. Poor market access is a considerable constraint to profitable dairy farming as many areas lack all-weather roads to major urban centres. Fresh raw milk, favoured by most rural and urban consumers, mainly due to lower cost, represents 80% of all milk marketed in Kenya. Ordinarily, farmers would sell morning milk and keep evening milk for home consumption (Omore, et al., 1999; Staal, et al., 2001). Likewise, the provision of input services has experienced dramatic changes in the last decade because policies have supported private enterprise as government support input services for dairy production has declined. The lack of efficient supply of inputs including livestock services however, is a serious constraint in almost all areas (Omore, et al., 1999).

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Chapter 3

Characterization of grade dairy cattle owning households in mixed small scale farming systems of Vihiga, Kenya

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ABSTRACT

This study characterized grade dairy cattle owning households, specifically understanding the farm system as influenced by grade dairy cattle production systems. Information was collected through a pre-tested structured questionnaire, administered to a purposive sample of 236 grade dairy cattle owning households from April to August 2005. Results obtained showed 0.76, 0.54, 0.58 and 0.24 acres of land were allocated to maize/beans, napier grass, tea and natural pastures/fallow land respectively. The major objectives in farming and dairying were food supply and milk for home consumption respectively. Cows comprised 45.02% of the grade dairy herd and heifers 23.05%. Cow ownership was significantly influenced by the production system and comprised mainly Ayrshire cross (33.1%) and Holstein-Friesian cross (30.5%). Cows produced 5.49 litres of milk/day and were 6.78 years old. Age at 1st calving was 31.11 months with a calving interval of 18.66 months. Calving interval, cow age and age at first calving were significantly influenced ($P<0.05$) by the production system. In conclusion, grade dairy cattle production and calving performance parameters were low, limiting optimization of productivity.

Key words: *Grade dairy cattle; Household characterization; Production systems; Production and calving performance indicators; Vihiga District, Kenya;*

3.1 INTRODUCTION

Smallholder systems all over the world show great diversity and complexity in the crops grown, cropping patterns, livestock species kept and the way they are managed. Given the wide diversity in agro-climatic, household and socio-economic conditions, grouping farms exhibiting closely related characteristics, which form unique recommendations domain, is not an easy task. There is a large amount of literature on characterizing farms and farming systems in Eastern Africa. For example Staal, et al., (1998) characterized 365 dairy farms in the central highlands of Kenya (Kiambu). Patterns among dairy households in terms of level of intensification, household resources and access to services and markets were distinguished by means of a cluster analysis. Shepherd and Soule, (1998) used participatory techniques to characterize mixed farming systems in Vihiga, Western Kenya, based on the resource endowments and constraints faced by farmers.

Nicholson, et al., (1999) characterized farming systems with respect to the adoption of livestock as a farm component. One aspect that was generally not considered in such studies was the fact that small holders have multiple goals and these drive their decision-making, particularly in the choice of technology and enterprise mixes. There is need, therefore, to characterize the dairy farming households, not only in terms of their resource availability, but also in terms of their household characteristics and objectives, production and management systems. The objectives of this study were to describe farm household characteristics and objectives of grade dairy cattle owning households within the mixed small scale farming systems and to quantify performance of grade dairy cattle under four production systems in Vihiga, Kenya.

3.2 MATERIALS AND METHODS

3.2.1 The study area

This study was conducted in Vihiga district of Western Kenya. The district has a high agricultural potential and is predominantly (95%) in the upper midland one (UM1) agro-ecological zone. Altitude is from 1300 to 1800 metres above sea level, while mean annual temperature is 20.3^{0}C. Soils comprise of well drained dystric acrisols and humic nitrisols (Jaetzold and Schmidt, 1983). The area receives bimodal rainfall that ranges from 1,800 – 2,000 mm/year.

3.2.2 Description of grade dairy cattle production systems

Waithaka, et al., (2002) characterized dairy cattle production systems in Western Kenya as being Grazing only (free grazing or tethered), Mainly grazing with some stall-feeding, Mainly stall-feeding with some grazing and Stall-feeding only (zero-grazing) based on the level of intensification and feeding systems. In intensive grade dairy cattle production systems (Stall feeding only and Mainly stall feeding with some grazing), animals are mainly stall fed ('cut-and-carry') with napier grass as the basal feed resource. While in extensive grade dairy cattle production systems (Grazing only and Mainly grazing with some stall feeding), animals are mainly grazed on natural pastures.

3.2.3 Data collection and analyses

A purposive sample of 236 grade dairy cattle owning households, irrespective of the grade dairy cattle production systems, were interviewed using a pre-tested structured questionnaire to elicit information on household characteristics; livestock inventory; herd structure, breed composition and herd dynamics; milk production and utilization; farming and dairying objectives, income sources and expenditures. Data collected were then segregated and analyzed based on the four existing grade dairy cattle production systems in Vihiga as described in 3.2.2 above. Descriptive statistics and frequencies were determined using SPSS (Version 10.0). Means were separated using LSD and ANOVA carried out based on the model:

$$\mathbf{Y_{jk} = \mu + P_j + e_{jk}}$$

Where: Y_{jk} = parameter under test (household characteristics; grade dairy cattle herd structure, dynamics and breed composition; milk production and utilization)

μ = the underlying constant in each observation

P_j = effect of the grade dairy cattle production system (Grazing only – free grazing/tethered; Mainly grazing with some stall feeding; Mainly stall feeding with some grazing and Stall feeding only - zero grazing) on test parameters

e_{jk} = error, ND($0,\delta_e^2$)

3.3 Results and Discussion

3.3.1 Land use and livestock ownership

The average farm size in Vihiga was 2.27 acres and this was similar (P>0.05) in all the four grade dairy cattle production systems (Table 3.1). Intensive production systems (Stall feeding only and Mainly stall feeding with some grazing) were the main grade dairy cattle production systems comprising 45.8% and 34.3% respectively. These results concur with Staal, et al., (2001) that due to continued sub division of land in successive generations may mean that in future, intensive grazing may be the predominant system for keeping dairy cattle. Grade dairy cattle households on average allocated 0.76 acres of the land to maize/beans (the main food crops), 0.54 acres to napier grass (main basal feed for dairy), 0.58 acres to tea (the main cash crop) and 0.24 acres to natural pastures/fallow land. Land allocated to napier grass and natural pastures/fallow highly depended on the production system (P<0.05).

These findings agree with Mwangi and Wambugu, (2003) that, as the size of land holdings has declined due to sub divisions, the contribution of pasture to livestock production has declined. Therefore, most livestock feed comes from planted forages and cropped land. Allocation of land to napier grass growing in Vihiga was similar to dairy production areas in Central Kenya as indicated by Staal, et al., (2001), though not optimal as per the recommendations of the National Dairy Development Project of 0.40 ha per cow and heifer per year (NDDP, 1989). Herd size for grade dairy cattle and zebu cattle was 3.55 and 1.89 respectively. Grade dairy cattle ownership was similar in all the four grade dairy cattle production systems (Table 3.1).

However, ownership of zebu cattle was significantly influenced ($P<0.05$) by the grade dairy cattle production system, similar to findings by Bebe, et al., (2003) that as farmers intensify their farming (production) systems, they adopt more of improved breed types and fewer of local cattle.

Each household had on average 17.34 local chickens, a major poultry in the area and these were similar across the four production systems (Table 3.1). Grade dairy cattle owning households in Vihiga were on average visited 4.66 times/year by the Ministry of Agriculture and Livestock Development Extension staff. These visits were, however, significantly influenced ($P<0.05$) by the grade dairy cattle production system, and were higher on farms where grade dairy cattle were kept under Stall feeding only and Mainly stall feeding with some grazing production systems. Intensive production systems are more productive than intensive ones and are likely to stimulate more extension visits per year (Wambugu, 2001).

Table 3.1. Household characteristics by grade dairy cattle production systems in Vihiga

Parameter	Grazing only	Mainly grazing + stall feeding	Mainly stall feeding + grazing	Stall feeding only
Number of households	10	37	81	108
Farm size (acres)	2.14 ± 0.39	2.39 ± 0.22	2.31 ± 0.16	2.20 ± 0.12
Family size	6.70 ± 0.84	5.35 ± 0.42	6.44 ± 0.27	6.42 ± 0.25
Dairy experience (years)	19.80 ± 3.65	15.59 ± 1.81	16.77 ± 1.36	16.08 ± 0.90
Age of HH (years)	57.40 ± 4.60	59.70 ± 1.73	56.21 ± 1.36	54.87 ± 1.00
Area under maize/beans	0.74 ± 0.17	0.78 ± 0.07	0.73 ± 0.07	0.77 ± 0.06
Area under napier grass*	$0.41^{a} \pm 0.04$	$0.45^{a} \pm 0.03$	$0.48^{ab} \pm 0.03$	$0.64^{b} \pm 0.04$
Area under pastures*	$0.63^{b} \pm 0.13$	$0.17^{a} \pm 0.03$	$0.27^{a} \pm 0.03$	$0.23^{a} \pm 0.02$
Area under tea	0.22 ± 0.06	0.75 ± 0.13	0.65 ± 0.07	0.52 ± 0.06
Grade dairy herd size	3.60 ± 0.56	3.68 ± 0.37	3.22 ± 0.18	3.74 ± 0.18
Zebu cattle herd size*	$3.50^{b} \pm 0.50$	$2.43^{a} \pm 0.27$	$1.63^{a} \pm 0.19$	$1.86^{a} \pm 0.14$
Number of local chicken	16.11 ± 3.81	18.18 ± 2.12	15.62 ± 1.27	18.52 ± 1.70
Extension visits per year*	$3.88^{a} \pm 0.77$	$4.07^{a} \pm 0.53$	$4.43^{ab} \pm 0.46$	$5.08^{b} \pm 0.36$

* Means significantly different *($P<0.05$)*

3.3.2 Calving performance, milk production and utilization

Lactating grade dairy cows in Vihiga were mainly milked by hand twice a day. The average milk production/household/day was 9.08 litres, while milk production/cow/day was 5.49 litres (Table 3.2). Milk production per cow per day was similar to findings by Waithaka, et al., (2002) who reported 5.1 litres/cow/day in Western Kenya and Gitau, et al., (1994) who reported 5.0 kg/cow/day for smallholder dairy farms in Kenya. Low milk production was attributed mainly to inadequate year-round supply of feed (quality and quantity) as similarly reported by Omore, et al., (1996) and Staal, et al., (1998). Grade dairy cattle production systems influenced ($P<0.05$) milk production/household/day but not milk production/cow/day ($P>0.05$). The average daily milk per household (hh) for home consumption, calf rearing and sales in Vihiga District was 1.96, 2.64 and 4.01 litres respectively. However, daily milk per household for home consumption and sales depended ($P<0.05$) on the production system. Milk sales were higher in stall feeding only and mainly stall feeding with some grazing production systems averaging 4.59 and 3.84 litres per household per day respectively.

Milk for home consumption on the other hand, was higher in grazing only and mainly grazing with some stall feeding production systems averaging 2.41 and 2.27 litres per household per day respectively (Table 3.3). These results are similar to findings by Omore, et al., (1999), Bebe, (2003), Waithaka, et al., (2002), Stotz, (1979) that extensive dairy production systems (only grazing and mainly grazing with some stall feeding) are more subsistence oriented while intensive production systems (stall feeding only and mainly stall feeding with some grazing) are commercial oriented with more marketed milk. Milk for calf rearing was least dependent ($P>0.05$) on the grade dairy cattle production system. Average age of grade dairy cows was 6.78 years and each cow had calved down 3.21 times (Table 3.2).

Table 3.2. Grade dairy cattle reproductive and production parameters by grade dairy cattle production systems in Vihiga

Parameter	Grazing only	Mainly grazing + stall feeding	Mainly stall feeding + grazing	Stall feeding only
Number of households	10	37	81	108
Calving interval (m)*	$22.56^{b} \pm 1.43$	$19.22^{ab} \pm 0.92$	$19.57^{ab} \pm 0.72$	$17.11^{a} \pm 0.65$
Cow age (yrs)*	$8.60^{b} \pm 0.56$	$6.63^{a} \pm 0.36$	$6.89^{a} \pm 0.30$	$6.54^{a} \pm 0.26$
Age at 1st calving (m)*	$32.72^{b} \pm 0.60$	$31.80^{ab} \pm 0.84$	$30.97^{ab} \pm 0.38$	$30.60^{a} \pm 0.29$
No. of calving/cow	3.40 ± 0.45	2.56 ± 0.25	3.14 ± 0.20	3.46 ± 0.20
Milk/cow/day (lts)	5.40 ± 0.78	5.04 ± 0.38	5.80 ± 0.27	5.44 ± 0.23
Milk/household/day (lts)*	$7.80^{a} \pm 0.57$	$9.04^{a} \pm 0.44$	$9.47^{ab} \pm 0.41$	$11.01^{b} \pm 0.43$
Milk for calf (lts/calf/day)	2.66 ± 0.15	2.64 ± 0.13	2.61 ± 0.11	2.66 ± 0.09
Milk sold (lts/hh/day)*	$2.62^{a} \pm 0.41$	$3.42^{ab} \pm 0.20$	$3.84^{ab} \pm 0.16$	$4.59^{b} \pm 0.30$
Milk consumed (lts/hh/day)*	$2.41^{b} \pm 0.16$	$2.27^{ab} \pm 0.11$	$1.85^{a} \pm 0.09$	$1.90^{a} \pm 0.08$
Age male calves weaned (m)*	$5.76^{b} \pm 0.23$	$5.48^{ab} \pm 0.32$	$4.71^{ab} \pm 0.20$	$4.40^{a} \pm 0.30$
Age female calves weaned (m)*	$6.11^{b} \pm 0.21$	$5.87^{ab} \pm 0.31$	$5.16^{b} \pm 0.21$	$4.50^{b} \pm 0.34$
Age male calves are sold (m)*	$21.89^{b} \pm 2.15$	$19.75^{ab} \pm 2.46$	$18.42^{ab} \pm 1.21$	$14.41^{a} \pm 0.82$
Age female calves are sold (m)*	$24.33^{b} \pm 1.67$	$20.85^{ab} \pm 1.01$	$17.83^{a} \pm 1.01$	$17.64^{a} \pm 0.82$

* Means significantly different *($P<0.05$)*

Age at first calving for grade dairy cows in Vihiga was 31.11 months and was highest for the grazing only system at 32.72 months compared to a low of 30.60 months for stall feeding only system. Age at first calving for grade dairy cows in Vihiga was within the range of 26.4 to 60 months reported for grade dairy herds on smallholdings in the Kenya highlands (Staal, et al., 2001, Waithaka, et al., 2002, Omore, et al., 1999). This finding, however, contrasts with Valk van der, (1992) who reported that dairy cattle in extensive production systems had lower age at first calving than those in intensive production systems due to the opportunity of constant exposure of heifers to bulls or other cows.

Both cow age and age at first calving were significantly influenced ($P<0.05$) by the grade dairy production system. Lower age at first calving for animals kept in intensive production systems (Stall feeding only and Mainly stall feeding with some grazing) could only be attributed to management and feeding. Calving interval for grade dairy cows was 18.66 months (559.8 days) and also depended ($P<0.05$) on the production systems (Table 3.2). These results were similar to Odima, et al., 1994, Staal, et al., 1998, and Waithaka, et al., 2002 that calving intervals averaging 600 days (20 months) are common on smallholder herds. Average age of grade dairy cows was 6.78 years and each cow had calved down 3.21 times (Table 3.2). Grade dairy male and female calves were weaned when they averaged 5.16 and 5.56 months old respectively. Weaning and sale ages for both male and female calves were significantly influenced ($P<0.05$) by the production system.

3.3.3 Grade dairy cattle breed types, herd structure and composition

Cows which had calved at least once comprised 45.02% of the grade dairy herd and each household had 1.70 cows on average. Ownership of grade dairy cows was highly influenced ($P<0.05$) by the production system (Table 3.3). Heifers comprised 23.05% of the grade dairy cattle herd and each household had 1.38 heifers. Production systems had no influence ($P>0.05$)

on heifer ownership. Preferred grade dairy cattle breed types were mainly 33.1% Ayrshire cross, 30.5% Holstein-Friesian cross and 13.6% Holstein-Friesian pure (Table 3.3).

However, majority (66.9%) of grade dairy cattle owning households in Vihiga chose preferred grade dairy cattle breed types without any professional advice. The other 30% of the grade dairy cattle owning households were influenced by extension advice, experience, neighbours and literature/media in choice of breed types. Preference for these breed types was mainly on account of high milk production and hence these breeds enabled grade dairy cattle owning households to meet their major objectives in farming in general (supply of food for the household) and dairying in particular (milk for household consumption and for sale).

This finding was in agreement with Bebe et al (2003) that in the Kenya highlands, market-oriented farmers gave top priority to the commercial objective of milk production in the choice of breed types in order to produce a marketable surplus for cash income. Stotz, (1979), Bebe, (2003) and Waithaka, et al., (2002) report that extensive dairy production systems (only grazing and mainly grazing with some stall feeding) are more subsistence oriented while intensive production systems (stall feeding only and mainly stall feeding with some grazing) are commercial oriented with more marketed milk. Milk for calf rearing was least dependent ($P>0.05$) on the grade dairy cattle production system. It is also important to note that the preferred breed types as indicated in Table 3.3 were the major (70%) starting breeds (foundation breeds) for grade dairy cattle owning households in all the production systems and were mainly acquired from other smallholder farmers (48.6%) and cattle markets (31.2%).

Table 3.3. Grade dairy cattle breed types, herd structure and composition by production systems

Parameter	Grazing only	Mainly grazing + stall feeding	Mainly stall feeding + grazing	Stall feeding only
Herd Structure				
Immature males (<3yrs)	< 1 ± 0.00	1.17 ± 0.17	1.31 ± 0.15	1.14 ± 0.08
Cows (calved at least once)	1.40 ± 0.22	2.00 ± 0.18	1.49 ± 0.08	1.81 ± 0.08
Heifers (post weaned, pre-calving)	1.57 ± 0.20	1.36 ± 0.12	1.31 ± 0.09	1.41 ± 0.09
Pre weaning males	< 1 ± 0.00	1.29 ± 0.18	1.14 ± 0.07	1.13 ± 0.06
Pre weaning females	< 1 ± 0.00	1.53 ± 0.26	1.30 ± 0.15	1.45 ± 0.13
Herd composition				
Holstein-Friesian pure	10%	5.4%	8.6%	20.4%
Holstein-Friesian cross	40%	32.4%	28.4%	30.6%
Ayrshire pure	10%	2.7%	6.2%	8.3%
Ayrshire cross	30%	40.5%	40.7%	25%
Jersey cross	-	-	3.7%	1.9%
Guernsey pure	-	-	1.2%	1.9%
Guernsey cross	-	5.4%	6.2%	3.7%

3.3.4 Objectives of farming and dairying for grade dairy cattle owning households

The main objective of farming was food supply as indicated by over 70% of the households irrespective of the production system (Table 3.4). However, differences across production systems come in their second main objective of farming. Fifty percent (50%) of the farmers who kept their grade dairy in Grazing only production system indicated that their second main objective of farming was soil improvement. Over 50% of the farmers who kept grade dairy cattle in each of the other production systems indicated that their second main objective of farming was income generation. Maximizing profits and social prestige/status were less important objectives of farming across the four production systems. These results show that in general grade dairy cattle farmers consider income generation their second most important objective in farming after provision of food. Milk for home consumption and surplus milk for sale were equally important as objectives of dairying in all production systems (Table 3.4).

However, the fact that grade dairy cattle owning households in Vihiga endeavor to satisfy their food needs before income generation implies some kind of risk aversion where the grade dairy cattle households are unwilling to rely on market for their household food requirements as similarly reported by Salasya (2005). Breeding stock for sale and capital assets building were indicated as third and fourth objectives of dairying by 37% and 25.9% of grade dairy cattle owning households who kept their grade dairy cattle in stall feeding only production system. Manure for sale was not a major objective for dairying across the four grade dairy cattle production systems in Vihiga.

Table 3.4. Distribution (%) of farming/dairying households' objectives, income sources and expenditure by grade dairy cattle production systems

Parameter	Grazing only	Mainly grazing + stall feeding	Mainly stall feeding + grazing	Stall feeding only
Farming Objectives				
• Food supply	70	86.5	90.1	90.7
• Income generation	20	51.4	65.6	50.9
• Maximize profits	-	8.1	5.0	13.0
• Soil improvement	50	24.3	18.8	23.1
• Social prestige/status	10	2.7	1.3	1.9
Dairying Objectives				
• Surplus milk for sale	70	64.9	76.5	77.4
• Milk for home consumption	70	70.3	79.0	78.5
• Manure for sale	10	10.8	21.0	13.0
• Breeding stock for sale	20	27.0	14.8	37.0
• Capital assets building	20	18.9	12.3	25.9
• Supplement income sources	20	24.3	22.2	22.2
Main household income sources per year				
• Farm income	60	51.4	65.0	57.4
• Off-farm income - employment, business	40	35.1	44.4	43.5
• Remittances	20	43.2	19.8	25.9
Farm income sources per year				
• Sale of dairy cattle milk	80	73.0	77.7	90.7
• Sale of dairy cattle animals	20	21.6	25.9	43.5
• Other livestock products	10	8.1	1.2	3.7
• Cash crops	20	8.1	7.4	13.0
• Food crops	20	13.5	19.8	21.3
• Horticultural crops	30	27.0	24.7	13.0
Farm expenditure per year				
• Food	50	45.9	44.4	45.4
• School fees	60	43.2	45.7	50.9
• Other livestock products	10	8.1	3.7	4.6
• Fertilizer	20	18.9	13.6	17.6
• Dairy cattle feeds and drugs	40	29.7	32.1	39.8
• Family health costs	20	32.4	34.6	22.2

3.3.5 Income sources and expenditures by grade dairy cattle owning households

Farming was the most important source of income per year for over 50% of households in all the production systems (Table 3.4). Off-farm income was the second main source of household income for 40%, 44.4% and 43.5% of the households under Grazing only, Mainly stall feeding with some grazing and Stall feeding only production systems respectively. Remittance was the second important source of income for 43.2% for households under Mainly grazing with some stall feeding. This finding contrasts Waithaka et al. (2002) who reported that the bulk of income to households in Western Kenya came from outside the farm, mainly by way of salaries and wage earnings from employment off-farm. The major source of farm income/year to 70% of households in all production systems was sale of milk (Table 3.4).

Sale of grade dairy animals was the second main source of farm income. Food crops were the third source of farm income for households under Stall feeding only. Horticultural crops (mostly bananas) were the third important source of farm income to 30%, 20% and 24.7% households under Grazing only, Mainly grazing with some stall feeding and Mainly stall feeding with some grazing respectively. Farm income from food crops and cash crops in the area was limited by the land size hence yields were very variable limiting sales as similarly reported by Salasya (2005). Other livestock products (poultry, sheep, goats etc) contributed less to farm incomes. Expenditure of household income per year was mainly on school fees and food irrespective of the grade dairy cattle production system (Table 3.4).

3.4 CONCLUSION

Because of the small land sizes per household and the need to satisfy households' requirements for food, grade dairy cattle owning households have adopted more of the intensive production systems (Stall feeding only and Mainly stall feeding with some grazing). The growing importance of grade dairy cattle in the mixed small scale farming systems is indicated by the amount of land allocated to napier grass and further by the prevalence of milking cows and heifers in the herds. Since food supply was the major objective of farming, it implies that farming in the area was mainly for subsistence. In general households considered income generation their second most important objective in farming after provision of food. The predominant breed types in the grade dairy cattle herds were Ayrshire cross, Holstein-Friesian cross and Holstein-Friesian pure and these bigger breeds were preferred over Guernsey and Jersey because of high milk yields. Generally production and calving performance parameters for grade dairy cattle were low, limiting optimization of productivity under the different grade dairy cattle production systems.

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C h a p t e r 4

Modeling the influence of existing feeding strategies on performance of grade dairy cattle in Vihiga, Kenya

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ABSTRACT

A modeling study was carried out on grade dairy cattle in four production systems in Vihiga District. The objective was to evaluate the effects of existing feeding strategies on performance of grade dairy cattle. Data for the model was extracted from results of a survey of 236 grade dairy cattle owning households in Vihiga District. Results showed that feeding strategies for grade dairy cattle in Vihiga District were sub-optimal reflected in low actual and potential milk yields per cow per day. Protein was a major limiting nutrient and the situation was serious during the dry season when low quality forages were available. Further, the cost of milk production was higher in intensive production systems as opposed to the extensive production systems. From the model used, the most optimum existing feeding strategies for Vihiga in terms of economic returns gross incomes by grade dairy cattle production systems were: a) The basal feed comprising napier grass cut and carry supplemented with dairy meal and protein rich fodder in stall feeding only and grazing only production systems, and b) The basal feed comprising natural pastures and napier grass cut and carry supplemented with dairy meal, protein rich fodder and crop residues in mainly stall feeding with some grazing and mainly grazing with some stall feeding production systems. In conclusion, supplementation of the basal diets with dairy meal and protein rich fodder as single supplements or components in compound feeding strategies was necessary in Vihiga for enhanced performance of grade dairy cattle in terms of milk yields, live weight gains, manure production and economic returns.

Key words: Grade dairy cattle; feeding strategies; performance; Vihiga District, Kenya.

4.1 INTRODUCTION

Smallholder mixed farming systems in Vihiga, Kenya are characterized by varied agricultural activities including cultivation of food crops and cash crops, as well as milk production (Bebe, et al., 2002; Salasya, 2005). Development of dairy systems on these smallholder farms is limited mainly by land shortage and hence feed supply among other factors resulting into low animal productivity (Odima, et al., 1994; Omore, et al., 1999; Staal, et al., 2001; Waithaka, et al., 2002). Strategies employed to alleviate the limited feed supply and hence improve animal productivity under different dairy cattle production systems include feeding of crop and agro-industrial by-products, fodder cultivation on roadsides and reliance on purchased fodder (Omore, et al., 1999; Mwangi, et al., 2003).

However, feeding strategies and practices adopted by farmers for their dairy cattle are often opportunistic, characterized by intermittent and abrupt changes in the quantity and quality of the feeds offered (Methu, et al., 2000, ILRI, 2001). Consequently, feeding strategies are not related to the expected nutritional requirements of the animals kept limiting performance (Delgado, et al., 2001; Bebe, 2003). This study was carried out to evaluate the influence of existing grade dairy cattle feeding strategies on milk yields, live weight changes, manure production, methane emissions and economic returns under four grade dairy cattle production systems in Vihiga.

4.2 MATERIALS AND METHODS

4.2.1 Study area

The study area is described in Chapter 3, section 3.2.1.

4.2.2 Data collection

Data for simulation analysis was summarized from a purposive sample of 236 grade dairy cattle owning households using a pre-tested structured questionnaire. Existing feeding strategies were stratified under four grade dairy cattle production systems in the area, namely stall feeding only, mainly stall feeding with some grazing, mainly grazing with some stall feeding and grazing only. Information was collected on feeds offered to grade dairy cattle under each feeding strategy (basal feeds and supplements) and their quantities, their cost per kilogram and milk yield per cow per day.

4.2.3. Data analysis

4.2.3.1 Model description

The Dairy Simulation Model *v3.2*, which is part of the Livestock Feeding Simulation "LIFE-SIM" Models group (Quiroz, et al., 2005) developed by the Natural Resources Department of the International Potato Centre (CIP) was used to model (simulate) the influence of existing feeding strategies on grade dairy cattle performance in terms of milk yield, economic gross margins, manure production and methane emissions under four grade dairy cattle production systems in Vihiga. The model is deterministic and its inputs include specific data for animal description, voluntary intake, nutrient requirements, milk production, manure production, methane emissions, thermal regulation, pasture growth and supplement availability. The model is fully described by Leon-Velarde, et al., (2005).

4.2.3.2 Model inputs

4.2.3.2.1. The animal

The average grade dairy animal was a 3.5 year old Ayrshire cross cow (the most common breed type in Vihiga) averaging 300 kg BW with a potential lactation yield of between 2000-2500 kg over a 305 day lactation period. The expected calf birth weight was 24kg and a lactation length of 10 months (301 days). The chemical composition of the cow's milk was 4.0%, 3.3%, 8% fat, protein content and solids not fat (S.N.F) respectively. The loss of weight during the first three month of lactation was estimated at 6%, within the range between 5-7% for crossbred cattle allowed by the model specifications.

4.2.3.2.2. Adjustment values

The energy (expressed in metabolisable energy, ME) and protein (expressed in terms of total protein, N*6.25) were adjusted by 6.5 Mcal/kg body weight (BW) and 20% based on the energy and protein concentration required to gain 1 kg of live weight respectively.

4.2.3.2.3. Potential dry matter intake (PDMI)

The potential dry matter intake was 3.12 kg/cow/day, determined from the reference table of live weight (LW) and metabolic weight (MW) provided in the model specifications. A stochastic variability of 5% was added to cater for the animal's inherent variable attitudes over a period of days. The correction factor for the influence of dry matter intake on milk production was 0.1, and this ranged between 0.1-0.15 in the model.

4.2.3.2.4. Potential milk yield

Potential milk yield was determined based on the four grade dairy cattle production systems in relation to the cow's body weight (i.e. 300kg BW for Ayrshire crosses), parameters for the milk production (lactation) curve derived from the Wood's equation (1967) quoted by Leon-Velarde, et al., (2005) and actual milk yield/cow/day. Therefore, the parameters for the lactation curve were: a = Actual milk yield, kg/cow/day for Vihiga (5.443, 5.801, 5.041, 5.40 for stall feeding only, mainly stall feeding with some grazing, mainly grazing with some stall feeding and grazing only production systems respectively, Ongadi, et al., 2007), b = 0.2582, and c = 0.00715. Once a, b and c were specified, the model automatically generated over 305 days lactation period, the yield at peak lactation, days at peak lactation and milk production per lactation.

4.2.3.2.5. Basal feeds

a) Natural pastures

The availability of natural pasture, the basal feed resource in extensive grade dairy cattle production systems (grazing only and mainly grazing with some stall feeding) in Vihiga was 350–700 kg DM/ha per year depending on the rainy season. The wet season was from March-July and October-November, while the dry season was from December to February and August-September. Natural pastures had a digestibility of 50-60% and a protein content of 4.5–7%. The energy cost of harvesting feed (grazing correction factor) was 5-30% of the maintenance requirements, accounting for locomotion. This value was lower for stall feeding only production system (5%) and higher for grazing only production system (30%). The stocking rate was 1.2A.U/ha (1A.U = 300kg of B.W).

b) Cut and carry

Fresh napier grass (*Pennisetum purpureum* Schum.), the basal feed resource, was offered at between 35–65kg per cow per day and had a dry matter content of between 17–22%. Fresh napier grass offered depended on grade dairy cattle production systems and rain seasons (wet and dry). More was offered under stall feeding only production systems as opposed to the other grade dairy cattle production systems. Digestibility of napier grass ranged between 50–65% depending on the season with a protein content of 7–10% (Schreuder et al., 1993).

4.2.3.2.6. Supplementation

Supplements were classified as (a) concentrate (dairy meal), (b) protein rich fodder that was a mixture of fodder legumes/fodder trees and sweet potato *(Ipomea batatus*) vines in the ratio of 0.3 (25%) and 0.7 (75%) respectively and (c) crop residue (mainly maize *(Zea mays)* stover). Nutrient contents of the supplements and basal feeds were specified into the model before formulating the different feeding strategies (rations) as indicated in Tables 4.1 and 4.2 of description of existing feeding strategies.

4.2.3.2.7. Cost

The calculated cost of natural pastures and napier grass was KES 0.67 and KES 1.25 respectively based on their estimated yields per ha. Napier grass yield was between 10 to 40 tonnes DM/ha (Schreuder et al., 1993) depending on soil fertility, climate and management. The yield of tropical natural pastures was 500kg DM/ha (Boonman, 1997). From figures obtained from the Ministry of Livestock and Fisheries Development, Vihiga district annual reports (Anonymous, 2004), the average yield of napier grass in the district was 20 tonnes DM/ha. The unit of trade was a wheelbarrow of napier grass weighing about 25kg and costing KES 50.00 on average. Therefore, one tonne of napier grass gave 40 wheelbarrows and 20 tonnes DM/ha gave 500 wheelbarrows costing about KES 25000.00 (500 x 50.00), which when divided by yield/ha in kilograms (i.e. 20000 kg DM/ha), gave a napier grass cost of KES 1.25.

The unit of trade of natural pastures in Vihiga was a sack-load of natural grass weighing about 15 kg and costing KES 10.00. Farmers in Vihiga gave away natural grass for free when available or sold for as little as KES 10.00 per sack-load. Therefore, a natural grass availability of 500 kg DM/ha gave about 33.33 sack-loads costing KES 333.33, which when divided by 500 kg DM/ha gave a cost of KES 0.67.

Feeding costs were 75-80% of the total milk production costs per year based on the level of intensification (grade dairy cattle production and feeding systems) and were higher for intensive production systems (stall feeding only and mainly stall feeding with some grazing) as opposed to extensive production systems (grazing only and mainly grazing with some stall feeding production system). The average cost of milk/litre in Vihiga was KES 30.00.

4.2.3.3 Description of existing feeding strategies

The main feeds for grade dairy cattle, summarized from the data were entered into the data base of feeds provided in the model. Their nutrient contents in terms of Dry matter (DM), Crude protein (CP), Digestibility (Dig) and Metabolisable energy, ME (Dig*3.64) as obtained from literature (Quiroz, et al., 2005: Leon-Velarde, et al., 2005; Abdulrazak, et al., 1996; Muinga, et al., 1992, 1993, 1995; Kariuki, 1998; Muia, 2000; Anindo, et al., 1986) and cost per kilogram of feed in KES were then specified. Once these were specified, the model automatically calculated the cost per ME (KES/Mcal) and CP (KES/kg) as indicated in Table 4.1. The feeds were categorized in the model as a) basal feeds (napier grass and natural pastures), b) supplement 1 which was the concentrate (dairy meal), c) supplement 2 which was protein rich fodder (a mixture of sweet potato vines and fodder legumes/trees in the ratio of 0.7 (75%) to 0.3 (25%) respectively) and d) crop residue which was mainly maize stover. Using the average quantities summarized from the data (Table 4.2), these feeds were then balanced and formulated to make the different feeding strategies or scenarios for grade dairy cattle production systems as indicated in Table 4.3. The model automatically generated the nutrient values of the formulated rations (feeding strategies) as indicated in Table 4.3.

4.2.3.4 Simulation

Scenarios were generated based on based the model inputs described above for every existing feeding strategy in each of the four grade dairy cattle production systems in Vihiga. The outputs of the dairy model included the expected milk yield during the lactation period, the changes in body weight during the same period, the amount of manure produced and an estimate of methane emissions.

4.2.3.5 Model validation

Average fresh feed intakes of the different grade dairy cattle feeds and actual milk yield per cow per day summarized from the data collected from grade dairy cattle owning households by grade dairy cattle production systems (Table 2) were fitted in the model to determine validity and accuracy of the model in assessing influence of existing feeding strategies on performance of grade dairy cattle in Vihiga.

4.2.3.6 Critique of the model

- The model adequately estimated and reflected reality on milk production per lactation for Vihiga, but tended to overestimate growth and live weight gains by mature grade dairy cows over the lactation period.
- The range of solids not fat (S.N.F) in milk specified in the model (i.e. 7.5-12%) was high and resulted in overestimation of total solids in milk.
- Calf birth weight was set default at 28.0kg, though Ayrshire crosses in Vihiga had a lower birth weight for calves (24.0kg).

4.3. RESULTS AND DISCUSSION

4.3.1 Basal and optimal feeding strategies

Basal feeding for each grade dairy cattle production system comprised napier grass alone, natural pastures alone or a combination of napier grass and natural pastures (Table 4.4). Dry matter intakes were higher for the optimal feeding strategies that is, when basal feeding strategies were supplemented with dairy meal and protein rich fodder (a mixture of sweet potato vines and fodder legumes/trees) in all the four grade dairy cattle production systems.

However, in all the four grade dairy cattle production systems in general, supplementation levels and hence dry matter intakes were low and this was reflected in performance (Table 4.4) for both the optimal and basal feeding strategies. Quantities of high protein forages were not adequate for supplementing lactating cows as similarly observed by Mwangi and Wambugu, 2003. In addition, supplementation using commercial concentrates was at minimal levels mainly because of the high costs in relation to milk prices (Abate and Abate, 1991; Abdulrazak, et al., 1996).

Table 4.1. Calculated nutrient content and cost/kg of different grade dairy cattle feed in Vihiga

Feed	DM %	ME (Mcal/kg DM)	Dig %	CP %	Cost (KE /kg feed)	ME Cost (KES/Mcal)	CP Cost (KES/kg)
Basal feeds							
Napier grass	18	2.0	55	8.0	1.2	0.6	15.0
Natural pastures	22	1.8	50	5.0	0.6	0.3	15.7
Supplement 1: Concentrate							
Dairy meal	85	2.7	75	15.0	10	3.7	66.7
Supplement 2: Protein rich Fodder							
Sweet potato vines	18	2.6	72	20	0.6	0.2	2.8
Fodder trees/legumes	30	2.1	59	25	1.5	0.7	6
Crop residue							
Maize stover	86	1.1	30	3.1	0.3	0.2	8.1

Table 4.2. Average daily fresh feed intakes (kg/cow/day) by grade dairy cattle production systems in Vihiga

Feed	Stall feeding only	Mainly stall feeding + some grazing	Mainly grazing + some stall feeding	Grazing only
Napier grass	54.4	45.8	38.5	-
Dairy meal	2.98	2.55	2.26	2.18
Natural pastures	-	11.7	18.6	39.4
Protein rich Fodder (Sweet potato vines, Fodder trees/legumes)	5.21	4.16	3.01	3.67
Crop residue	6.14	6.06	6.31	7.63
Mineral salt	0.1	0.1	0.1	0.1
Total feed intake, kg/cow/day	68.8	70.4	69.8	53.0
Actual milk, kg/cow/day	5.44	5.80	5.04	5.40

Note: Natural pastures and napier grass fed in either Stall feeding only or Grazing only production systems were summed up with the basal feed in those systems.

Protein rich fodder was a mixture of sweet potato vines and fodder legumes/trees in the ratio of 0.7 to 0.3 respectively

Table 4.3. Calculated nutrient values and cost/kg of existing grade dairy cattle feeding strategies by production systems in Vihiga

Grade dairy cattle feeding strategies by production system	DM %	ME (Mcal/ kg DM)	Dig %	CP %	Cost (KE /kg feed)	ME Cost (KE/Mcal)	CP Cost (KE/kg)
Stall feeding only							
• Napier grass alone	18	2.0	55	8.0	1.2	0.6	15.0
• Napier grass + dairy meal + protein rich fodder + crop residue	27.6	1.8	50.6	7.7	1.5	0.8	19.6
• Napier grass + dairy meal + crop residue	27.7	1.8	50.4	7.5	1.5	0.8	20.2
• Napier grass +dairy meal + protein rich fodder	21.5	2.1	59.2	9.7	1.7	0.8	17.0
• Napier grass + dairy meal	21.5	2.1	59.1	9.4	1.7	0.8	17.6
Mainly stall feeding with some grazing							
• Napier grass and natural pastures alone	18.8	1.9	53.8	6.9	1.1	0.6	15.4
• Napier grass and natural pastures + dairy meal + protein rich fodder + crop residue	27.4	1.8	49.7	7.0	1.3	0.7	19.1
• Napier grass and natural pastures + dairy meal	21.6	2.1	57.3	8.3	1.4	0.7	17.5
• Napier grass and natural pastures + dairy meal + crop residue	27.5	1.8	49.5	6.8	1.3	0.7	19.7
• Napier grass and natural pastures + dairy meal + protein rich fodder	21.6	2.1	57.5	8.5	1.4	0.7	16.9
Mainly grazing with some stall feeding							
• Natural pastures and Napier grass alone	19.3	1.9	53.1	6.3	1.0	0.5	15.6
• Natural pastures and Napier grass + dairy meal + protein rich fodder + crop residue	27.8	1.7	48.8	6.4	1.2	0.7	18.8
• Natural pastures and Napier grass + dairy meal	21.8	2.0	56.3	7.5	1.3	0.6	17.5
• Natural pastures and Napier grass + dairy meal + crop residue	27.9	1.8	48.6	6.2	1.2	0.7	19.5
• Natural pastures and Napier grass + dairy meal + protein rich fodder	21.8	2.0	56.4	7.8	1.3	0.6	16.8
Grazing only							
• Natural pastures alone	22	1.8	50	5.0	0.6	0.3	15.7
• Natural pastures + dairy meal + protein rich fodder + crop residue	34.4	1.6	45.2	4.8	0.9	0.5	19.0
• Natural pastures + dairy meal	25.3	2.0	54.3	5.5	1.0	0.5	18.9
• Natural pastures + dairy meal + crop residue	34.7	1.6	45.0	4.6	0.9	0.6	20.1
• Natural pastures + dairy meal + other fodder	25.2	2.0	54.6	5.8	1.0	0.5	17.6

Note: Protein rich fodder was a mixture of sweet potato vines and fodder legumes/trees in the ratio of 0.7 to 0.3 respectively

As indicated in Figures 1a and b, dry matter intake of basal and optimal feeding strategies varied over the lactation period, mainly due to the seasons (wet and dry) that influenced feed availability. Dry matter intake was higher during the wet season than the dry season. It was also lower in extensive production systems (grazing only and mainly grazing with some stall feeding) compared to intensive production systems (Table 4.4). Deficiencies in energy and protein supply to grade dairy cows were greater with the basic feeding strategies in all production systems, affecting dry matter intakes, milk production and live weights (Figure 1). Difficulties in bridging these gaps in energy and protein supply were as a result of inadequate forage both in quantity and quality for the grade dairy cattle. This was mainly because of diminishing land sizes and seasonality in forage production.

4.3.2 Simulated live weight change

Simulated live weight at the end of lactation (301 days), live weight at the end of the year (365 days) and live weight after calving were lower when grade dairy cows were fed basal diets alone without supplementation in all production systems (Table 4.5). Similarly, average daily weight change (gain or loss) after end of lactation and per year was lower when cows were offered basal diets without supplementation. Inclusion of crop residue in the feeding strategies resulted into higher live weight at the end of lactation, at the end of year and after calving in all the production systems except grazing only (Table 4.5).

Live weight change during the lactation period in all the four grade dairy cattle production systems highly depended on the quantity and quality of dry matter intake from all the existing feeding strategies. Live weight change by lactating cows from existing feeding strategies, was influenced more by protein than energy supply during the lactation period. The influence varied with the rainy season (wet and dry) as indicated in Figures 2a and b. Initially cows lost weight, during the first few months of lactation but eventually regained weight as lactation progressed (Figures 2a and b).

Figure 1a. Simulated influence of basal feeding strategies on Dry Matter intake

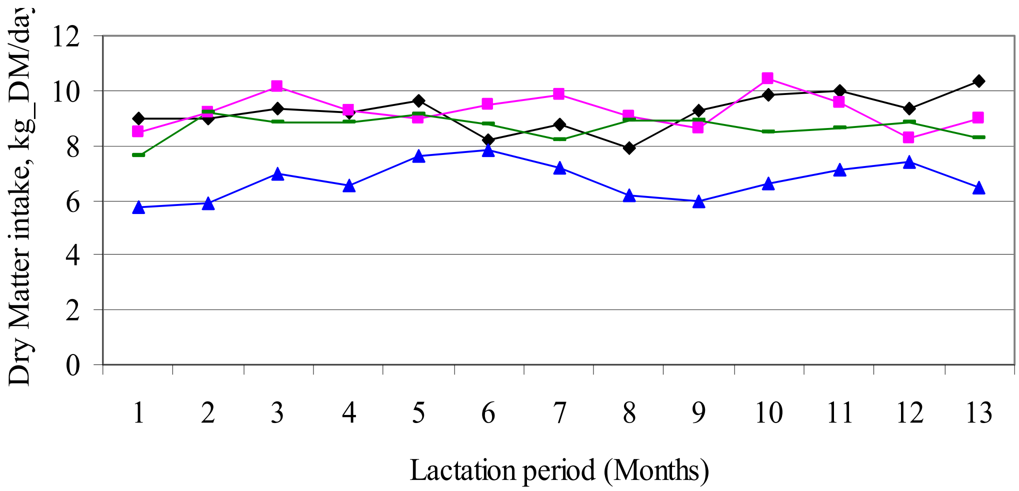

Figure 1b. Simulated influence of optimal feeding strategies on Dry Matter intake

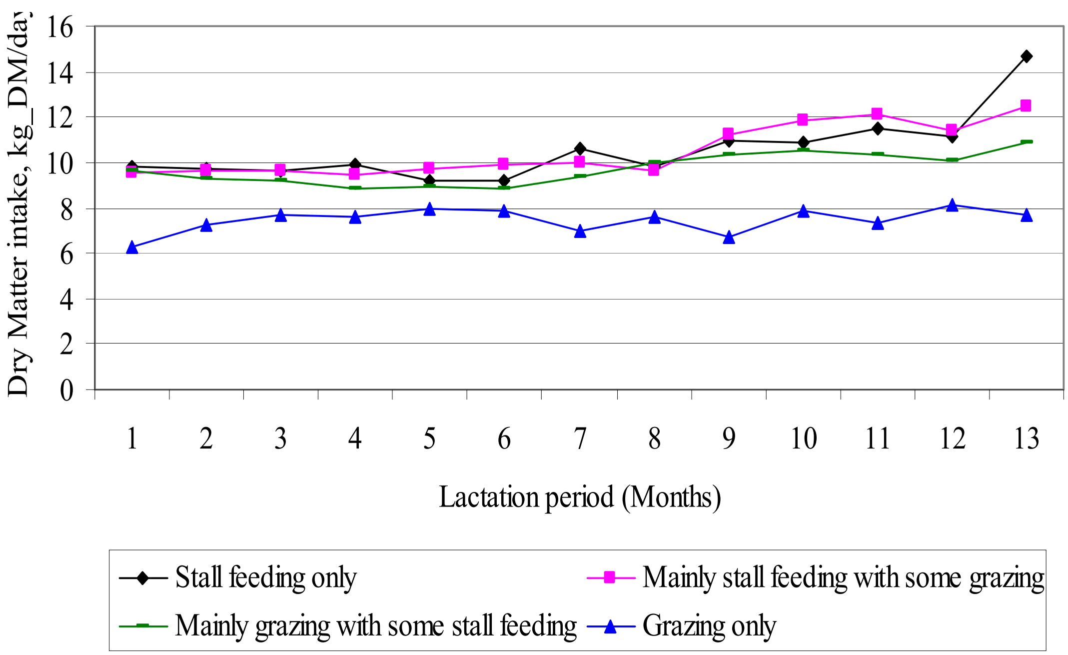

Table 4.4. Simulated average performance from basal and optimal existing feeding strategies for grade dairy cattle by production systems in Vihiga

Feeding strategy	DM Intake, kg/cow/day	Live weight, kg	Potential milk yield, kg/cow/day	Actual milk yield given available protein and energy intake, kg/cow/day*
Stall feeding only				
• Napier grass alone	9.2	300.2	5.4	5.4
• Napier grass +dairy meal + protein rich fodder	10.5	330.2	9.9	5.8
Mainly stall feeding with some grazing				
• Napier grass + natural pastures alone	9.2	292.2	5.8	5.1
• Napier grass and natural pastures + dairy meal + crop residue + protein rich fodder	10.5	328.2	8.8	5.8
Mainly grazing with some stall feeding				
• Natural pastures and napier grass alone	8.7	291.0	5.1	5.0
• Natural pastures and napier grass + dairy meal + crop residue + protein rich fodder	9.7	311.0	7.3	5.5
Grazing only				
• Natural pastures alone	6.7	293.5	5.4	5.0
• Natural pastures + dairy meal + protein rich fodder	7.5	298.7	6.7	5.4

* - The cows would fail to attain the potential milk yield/cow/day given available energy and protein intake (kg/day) as the existing feeding strategies (feed) could not supply adequate energy and protein.

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However, cows lost weight towards the end of lactation when their basal diets comprised natural pastures or a combination of napier grass and natural pastures without supplementation as similarly observed by Kariuki, (1998) and Muia et al., (1999). The lower milk yields and greater weight losses in cows offered basal diets only, compared to those offered basal diets supplemented with concentrates reported by Anindo and Porter, 1986; Muinga, et al., 1993 or forage legumes by Muinga, et al., 1995; Abdulrazak, et al., 1996 were consistent with the simulated results.

4.3.2 Simulated milk production

Lactation and daily milk production for grade dairy cattle was lower than potential milk production in all production systems in Vihiga (Tables 4.4 and 4.6). The production was lower when cows were offered basal diets without supplementation. Inclusion of dairy meal and protein rich fodder in the feeding strategies resulted in increased milk production in all production systems.

Lactation milk production was more innately related to the protein supply than energy supply from existing feeding strategies under all production systems (Figures 3a and b). This was similar to experimental findings that higher milk yields could be obtained when basal diets were supplemented with high energy and protein content feed resources (Combellas and Martinez, 1982; Anindo and Porter, 1986; Van Bruchem, et al., 1989; Muinga, et al., 1992, 1995; and Mukisira, et al., 1994).

In general, potential and actual lactation milk yield with basal and optimal feeding strategies was far below the genetic potential of the grade dairy cattle (Figures 3a and b) and was attributed to inadequate levels of feeding with existing feeding strategies and low quantity and quality of basal diets, especially during the dry season, as similarly observed by Valk, et al., (1990), Reynolds, et al., (1996) and Bebe, (2003).

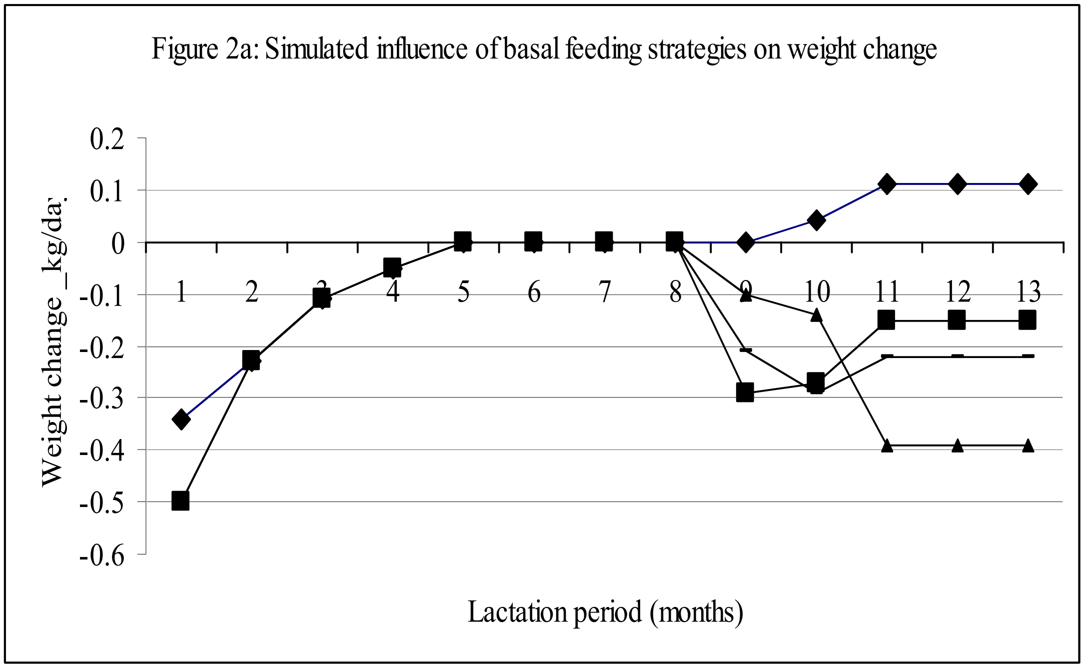


Figure 2a: Simulated influence of basal feeding strategies on weight change
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
1
2
3
4
5
6
7
8
9
10
11
12
13
Weight change _kg/day
Lactation period (months)

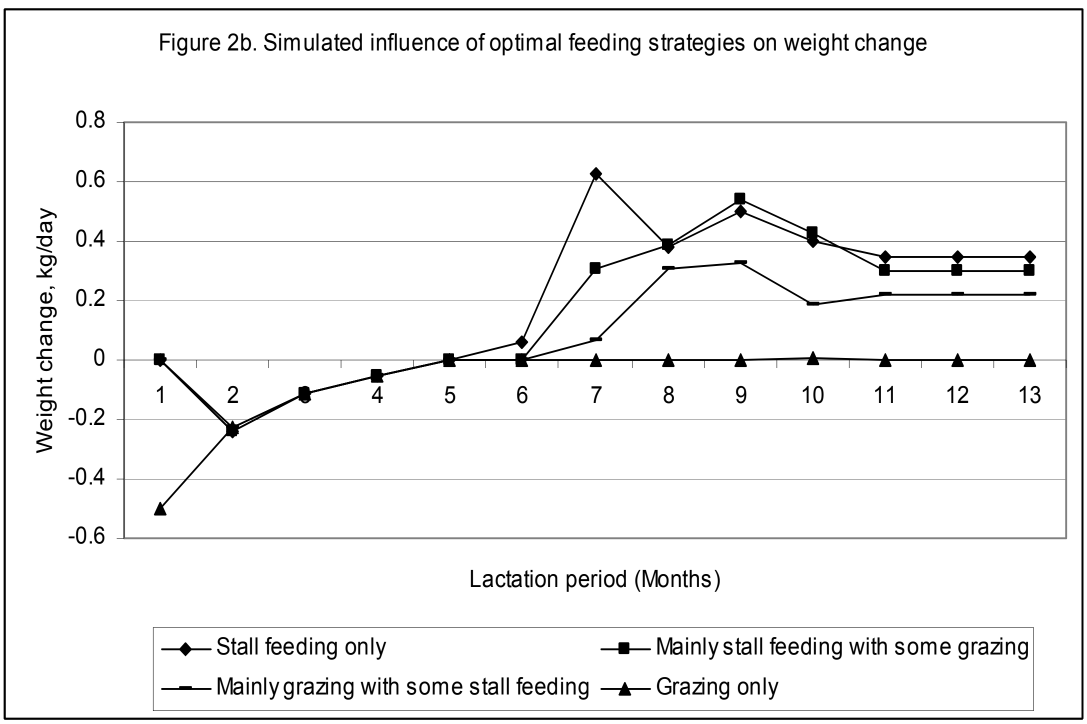


Figure 2b. Simulated influence of optimal feeding strategies on weight change
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1
2
3
4
5
6
7
8
9
10
11
12
13
Weight change, kg/day
Lactation period (Months)
Stall feeding only
Mainly stall feeding with some grazing
Mainly grazing with some stall feeding
Grazing only

Table 4.5. Simulated influence of basic and optimal existing feeding strategies on live weight changes of grade dairy cows by grade dairy cattle production systems in Vihiga

Feeding strategy	LW after calving, Kg	LW at end of lactation (301days), Kg	LW at end of year (365 days), Kg	Av. Daily weight change/ year (365 days), Kg/day	Av. Daily wt. Change after lactation end (301 days), Kg/day
Stall feeding only					
• Napier grass alone	300.0	329.7	339.0	0.106	0.143
• Napier grass +dairy meal + other fodder	380.3	384.9	413.2	0.309	0.436
Mainly stall feeding with some grazing					
• Napier grass + natural pastures alone	257.9	296.7	290.3	-0.026	-0.098
• Napier grass and natural pastures + dairy meal + crop residue + other fodder	359.8	377.3	399.4	0.272	0.342
Mainly grazing with some stall feeding					
• Natural pastures and napier grass alone	260.2	310.3	303.9	0.011	-0.099
• Natural pastures and napier grass + dairy meal + crop residue + other fodder	320.0	348.9	361.4	0.168	0.193
Grazing only					
• Natural pastures alone	246.8	305.9	285.9	-0.038	0.307
• Natural pastures + dairy meal + other fodder	286.3	318.9	324.7	0.068	0.091

4.3.3 Simulated waste production

Feeding basal feeds comprising napier grass alone or napier grass and natural pastures resulted into more manure production/cow/year than when animals were fed natural pastures alone in grazing only production system (Table 4.6). Similar to observations by Lekasi, et al., (1998), manure production was higher in all production systems where napier grass was included as a basal feed in feeding strategies. Generally, natural pastures based feeding strategies in Grazing only production system resulted into the lowest manure production/cow/year.

Methane, a by-product of milk production, was low when basal diets were offered without supplementation in all production systems (Table 4.6). Further, natural pastures based feeding strategies in grazing only production system resulted into the lowest methane emissions/cow/year. While, intensive napier grass based feeding strategies in stall feeding only and mainly stall feeding with some grazing had the highest methane emissions/cow/year. Ulyatt, et al., 1997 and Pradel, et al., 2006 supports our findings that pasture and fodder quality and feed intake were innately positively linked and thus when pasture/fodder digestibility increased, consumption also increased leading to more methane emissions, as is the case in intensive grade dairy cattle production systems (stall feeding only and mainly stall feeding with some grazing).

4.3.4 Simulated economic assessment

Lower total production costs, gross incomes, gross margins/cow/year, daily gross incomes/kg milk and income-cost ratios were realized from feeding strategies that comprised basal feeds alone without supplementation in all production systems (Table 4.6). In fact, heavy losses were realized in all production systems except grazing only when basal diets were offered without supplementation. Production costs per kilogram of milk were, however, higher when basal feeds were offered without supplementation. Gross incomes from milk were higher from exiting feeding strategies utilized in intensive production systems (stall feeding only and mainly stall feeding with some grazing) as opposed to extensive production systems (mainly grazing with some stall feeding and grazing only). Similarly, feeding napier grass supplemented with protein rich fodders in stall feeding only production system resulted in higher income from milk (Table 4.6).

Feeding natural pastures supplemented with dairy meal and natural pastures supplemented with dairy meal and protein rich fodders in grazing only production system, though resulting in lower gross incomes than in the other production systems, had the highest gross margins, daily gross income/kg milk and income-cost ratios as a result of lower production costs per kilogram of milk. Feeding napier grass alone or in combination with natural pastures without supplementation in all production systems except grazing only resulted in loss of revenue because of the high costs of napier grass production as similarly observed by Muia, (2000). Generally, supplementing basal diets for existing feeding strategies in all production systems resulted into increased returns. The high costs of milk production with existing feeding strategies under intensive production systems as opposed to extensive systems reflected high cost of concentrate feed used (Staal, et al., 2003).

Table 4.6. Simulated influence of basic and optimal existing feeding strategies on lactation milk and manure production, methane emissions and economic performance of grade dairy cows by grade dairy cattle production systems in Vihiga

Feeding strategy	Potential milk yield ,kg/cow/yr	Actual milk yield ,kg/cow/yr	Total Production costs, KES/cow/yr	Gross income, KES/cow/yr	Gross margin, KES/cow/yr	Cost/kg milk, KES	Daily gross income/kg milk, KES	Income -cost ratio	Manure excretion, kg DM/cow/yr	Total methane emission, litres/cow/yr
Stall feeding only										
• Napier grass alone	1647	1647	31248	19729	-11519	47.5	-17.6	0.6	1447	116.7
• Napier grass +dairy meal + protein rich fodder	3020	1769	41202	48655	10599	23.9	6.1	1.2	1162	121.9
Mainly stall feeding with some grazing										
• Napier grass + natural pastures alone	1769	1556	24600	7052	-17548	104.7	-17.7	0.3	1529	103.0
• Napier grass and natural pastures + dairy meal + crop residue + protein rich fodder	2684	1769	34192	43452	9261	23.6	6.4	1.3	1265	129.6
Mainly grazing with some stall feeding										
• Natural pastures and napier grass alone	1556	1525	21107	7525	-13582	84.2	-54.2	0.4	1384	97.6
• Natural pastures and napier grass + dairy meal + crop residue + protein rich fodder	2227	1678	29357	36349	6992	24.2	5.8	1.2	1352	121.8
Grazing only										
• Natural pastures alone	1647	1525	7894	9013	1119	26.3	3.7	1.1	833	76.3
• Natural pastures + dairy meal + protein rich fodder	2044	1647	15671	31460	15789	14.9	15.1	2.0	866.8	82.5

Figure 3a. Simulated influence of basal feeding strategies on potential and actual milk yield

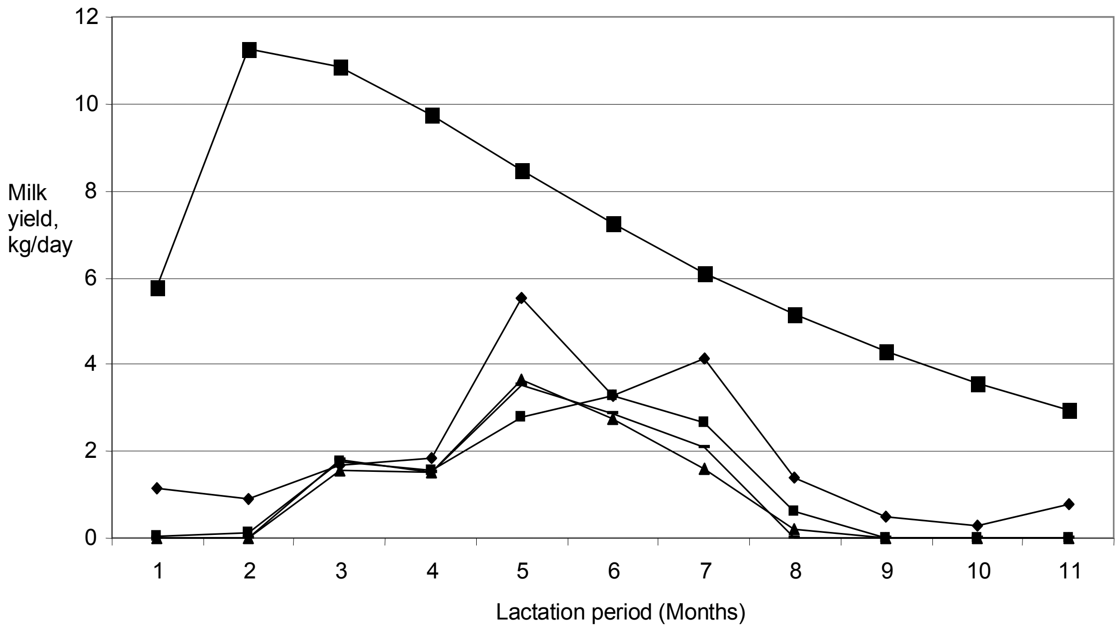
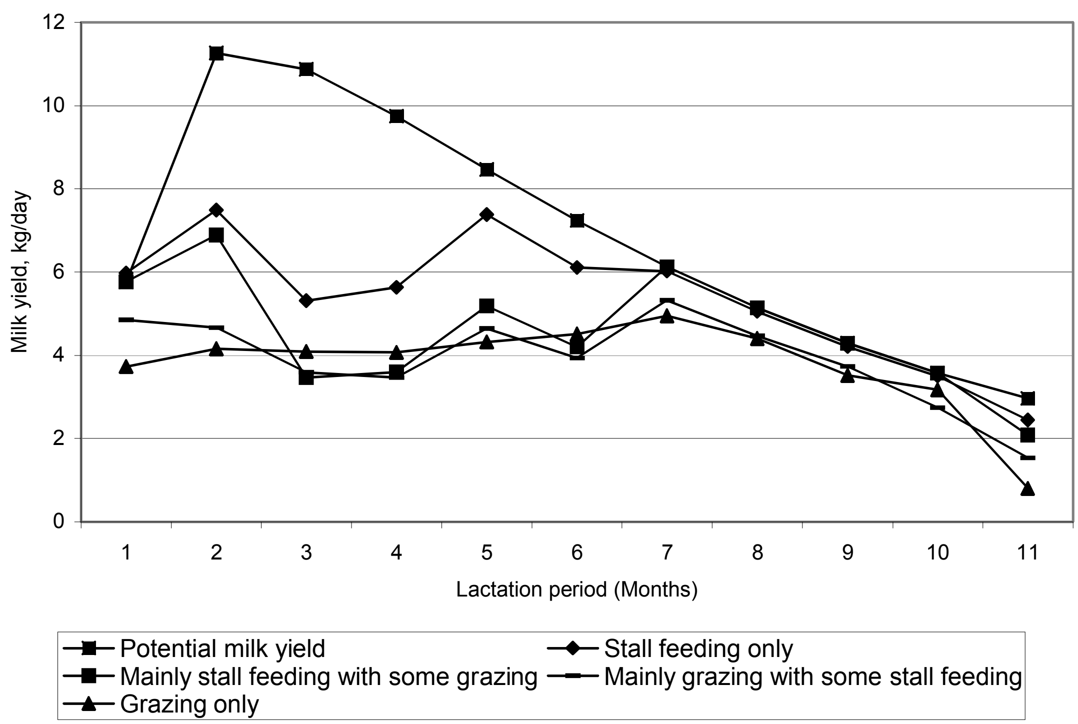


Figure 3b. Simulated influence of optimal feeding strategies on potential and actual milk yield



4.4 CONCLUSION

Basic feeding strategies for grade dairy cattle were sub-optimal, and resulting in failure to realize the full economic and production potential of grade dairy cattle. Inadequate protein nutrition was a major limiting factor to performance of grade dairy cattle in Vihiga. Costs of milk production and incomes were higher from existing feeding strategies utilized in intensive production systems as opposed to the extensive production systems. Simulated results indicated the most optimum existing feeding strategies for Vihiga in terms of economic returns by grade dairy cattle production systems as: a) napier grass supplemented with dairy meal and protein rich fodder in stall feeding only and grazing only production systems, and b) natural pastures and napier grass supplemented with dairy meal, protein rich fodder and crop residue in mainly stall feeding with some grazing and mainly grazing with some stall feeding production systems. From this study, supplementation of the basal diets with dairy meal and protein rich fodder (e.g. sweet potato vines and fodder legumes/trees) as single supplements or components in compound feeding strategies was necessary in Vihiga for enhanced performance from grade dairy cattle in terms of milk yields, live weight gains, manure production and economic returns.

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Chapter 5

Bio-economic analysis of expenditure on inputs and output value from crops and grade dairy cattle sub systems in Vihiga, Kenya

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ABSTRACT

This study analyzed expenditure on inputs and output value from crops and grade dairy cattle sub-systems and contribution to grade dairy cattle owning households' farm incomes in Vihiga. Information was collected through a pre-tested structured questionnaire, administered to a purposive sample of 236 grade dairy cattle owning households from April to August 2005. Results obtained showed that grade dairy cattle production systems significantly influenced ($P<0.05$) total household expenditure on inputs and output value for the grade dairy cattle sub-system and tea crop for the crops sub-system. On the contrary, grade dairy cattle breed types had no substantial influence ($P>0.05$) on total household expenditure on inputs and output value from both grade dairy cattle and crops sub-systems. Further, both grade dairy cattle production systems and breed types had little influence ($P>0.05$) on gross margins of the two sub systems. The cash output - input ratios for grade dairy cattle and crops sub systems in the four production systems were above 2.0. There was little interaction ($P>0.05$) between production systems and breed types. Generally, grade dairy cattle contributed 70% of the total grade dairy cattle owning households' farm income while crops contributed 30% highlighting its importance in mixed small scale farming systems.

Key Words: Crops and grade dairy cattle sub-systems; Expenditure on inputs; Output values

5.1 INTRODUCTION

Dairy farming in the mixed small scale farming systems of Western Kenya ranks second to maize and beans in contribution to household incomes and food security (Wangia, 1998). However, recent studies (Waithaka, et al., 2002) indicate that production and profitability indices are lower than could have been realized from the favourable climatic conditions and relatively high genetic potential of the grade dairy cattle in the area. The challenge is to determine whether the dairy cattle represent a burden on the system (McDowell and

Hilderbrand, 1980; Udo, et al., 1992; Chilonda, et al., 2000), consuming resources that could be used to increase crop productivity or whether the mixed small scale farmer utilizes the animals to improve outputs of the mixed farm system (Zemmelink, et al., 1999; Utiger, et al., 2000).

There is need for systematic analysis of expenditure on inputs and output value from grade dairy cattle and crops sub-systems (Baars, et al., 1996; Patil and Udo, 1997; Hella, et al., 2001; Phung and Koops, 2003; Widodo, et al., 1994a and b; Lanyasunya, et al., 2005) in the existing grade dairy cattle production systems of Vihiga, Kenya. In addition, information is required to support grade dairy enterprise development due to the changing farming systems, increased demand for dairy products (Rijk de Jong 1996; Delgado, et al., 2001; Nicholson, et al., 2001) and opportunities or increased financial incentives for investment in dairy cattle enterprises (Islam 1995; Morton and Mathewman 1996). The purpose of this study therefore, was to quantify and analyze expenditure on inputs and output value from crops and grade dairy cattle sub-systems and thereby determine their respective contribution to grade dairy cattle owning households' farm incomes.

5.2 MATERIALS AND METHODS

5.2.1 Study Area

The study area is described in Chapter 3, section 3.2.1.

5.2.2 Description of grade dairy cattle production systems

Grade dairy cattle production systems are described in Chapter 3, section 3.2.2.

5.2.3 Data collection and analysis

A purposive sample of 236 grade dairy cattle owning households were interviewed using a pre-tested structured questionnaire from April to August 2005 to collect information on expenditure on inputs such as feeds and supplements; drugs and vaccines; replacement stock and breeding services for the grade dairy sub-system. From the crops sub-system, information was collected on expenditure on inputs such as seed, fertilizer, land preparation, tea production and manure. Similarly, information on output values from both the grade dairy and crop sub-systems was also captured separately. The data were entered into MS EXCEL spreadsheet and gross margins for the two sub-systems calculated directly by subtracting total expenditure on inputs from total output value.

Expenditure on inputs and output value expressed in KES for the grade dairy cattle sub system were calculated per cow per year and per household per year for the crops sub system (Phung and Koops, 2003). Descriptive statistics and ANOVA were determined from the General Linear Model procedure (Angela and Daniel, 1999) from the SPSS package (Version 10.0) based on the model:

$$\mathbf{Y_{jkl} = \mu + P_j + B_k + e_{jkl}}$$

Where: Y = parameters under test (Expenditure on inputs such as feeds, drugs and vaccines, replacement stock, breeding services, seed, manure, tea production, land preparation and output value such as milk, manure, breeding stock, tea, maize, beans, horticulture etc from crops and grade dairy cattle sub systems)

μ = the underlying constant in each observation

P_j = effect of the grade dairy cattle production system (Grazing only - free grazing or tethered; Mainly grazing with some stall feeding; Mainly stall feeding with some grazing and Stall feeding only - zero grazing) on expenditure on inputs and output value for the two sub systems

B_k = Effect of the grade dairy cattle breed types (Holstein-Friesian pure, Holstein-Friesian cross, Ayrshire pure, Ayrshire cross, Jersey cross, Guernsey pure and Guernsey cross) on expenditure on inputs and output value from the two sub systems

e_{jkl} = error ND$(0,\delta_e^2)$

5.3 RESULTS AND DISCUSSION

5.3.1 Expenditure on inputs in the grade dairy cattle sub-system

5.3.1.1 Feeds

Expenditure incurred on feeds such as dairy meal, napier grass and minerals supplement largely depended ($P<0.05$) on the grade dairy cattle production system and less ($P>0.05$) on the breed type (Table 5.1). As indicated in Table 5.2, households that reared their grade dairy cattle under intensive production systems (Stall feeding only and Mainly stall feeding with some grazing) incurred significantly higher ($P<0.05$) expenditure per cow per year on dairy meal, minerals and napier grass, as opposed to those that reared them under extensive production systems (Mainly grazing with some stall feeding and Grazing only). There was higher expenditure on maize stover in extensive production systems than in intensive production systems (Table 5.2).

Expenditure on other feed stuffs like molasses, hay/straw and protein rich fodder was minimal under all the four grade dairy cattle production systems. Grade dairy cattle owning households were confronted with consistent pressure on land and hence animal feeds, necessiting intensification of management systems through adoption of intensive production systems (stall feeding only and mainly stall feeding with some grazing) and greater use of purchased forages and supplements as similarly observed by Bebe (2003). Also consistent with observations by Zemmelink, et al., (1999), grade dairy cattle owning households gave priority to growing food crops, explaining higher expenditures on napier grass.

5.3.1.2 Veterinary services

Expenditure incurred per cow per year on tick control (accaricide/dipping) was dependent ($P<0.05$) on the grade dairy cattle production system (Table 5.1). However, expenditure on vaccination and drugs/antihelminthics was least dependent ($P>0.05$) on the grade dairy cattle production system. Grade dairy cattle breed types had little influence ($P>0.05$) on all expenditures incurred on veterinary services (Table 5.1). As indicated in Table 5.2, households that reared their grade dairy cattle under Stall feeding only and Mainly stall feeding with some grazing production systems incurred slightly higher expenditure on accaricide/dipping (KES 693.1 and 693.9 respectively) as opposed to those that reared them under Grazing only and Mainly grazing with some stall feeding (KES 433.8 and 512.0 respectively). Farmers who reared their animals intensively attached more value to their stock resulting into more allocation of their resources to tick control. Expenditure on vaccination and drugs/antihelminthics was similar under the four production systems.

5.3.1.3 Breeding services

Expenditure incurred by grade dairy cattle owning households per cow per year on artificial insemination (AI) and bull service was not dependent ($P>0.05$) on grade dairy cattle production systems or breed types (Table 5.1). Use of Artificial insemination (AI) in Vihiga was, however, low as prices paid for AI services depended on the sire selected and transport costs incurred by the provider for each insemination (regardless of repeats), and in most cases was not affordable to the average small scale dairy farmer. On the contrary, bull services due to lower costs for each successful service were affordable to most small scale dairy farmers hence widely used for breeding in the area (Table 5.2).

5.3.1.4 Labour

Expenditure incurred by grade dairy cattle owning households on hired labour for dairying activities per cow per year was dependent ($P<0.05$) on the production system and less ($P>0.05$) on the breed type (Table 5.1). Farmers who intensively managed their grade dairy cattle (Stall feeding only and Mainly stall feeding with some grazing) incurred higher expenditure on hired labour for dairying activities (KES 13,200.0 and 10,873.6 respectively) as indicated in Table 5.2. Low expenditure on labour for dairying activities was incurred in Grazing only production system (KES 5812.5). This finding was supported by Staal et al (2001) and Waithaka et al (2002) that for the intensified stall feeding systems (Zero grazing and Mainly stall feeding with some grazing), labour (hired and/or casual) was necessary to carry out 'cut and carry' feeding activities (labour intensive), while in the extensive systems where animals are mainly grazed, labour is only required for herding. Hired labour for dairying activities on these farms was partly used on cropping activities.

5.3.1.5 Breeding stock

Both the grade dairy cattle production systems and breed types had little influence ($P>0.05$) on expenditure incurred by grade dairy cattle owning households for purchasing the breeding stock (calves, heifers, cows and bulls) as indicated in Table 5.1. This implied that acquisition of breeding stock was not necessarily based on knowledge of appropriate production or management systems, rather an effort towards improving quality of their stock. However, more heifers and cows were purchased in the intensive production systems (stall feeding only and mainly stall feeding with some grazing). As Bebe (2003) reports, high reproductive wastage and high turnover of females under intensive systems is such that they are unable to maintain a sufficient number of heifers for replacing cows leaving the herd without external supply of replacement. Hence farmers practicing intensive systems purchase more replacement animals than those practicing extensive systems.

Table 5.1. Summary ANOVA for influence of grade dairy cattle production systems and breed types on expenditure on inputs and output value per cow per year from the grade dairy cattle sub system in Vihiga.

Parameter	EMS ('000)	Production systems		Breed type	
		MS ('000)	F value	MS ('000)	F value
Expenditure on grade dairy cattle inputs/cow/year					
Dairy meal	6718	3194	4.76*	40023	0.60
Hay/straw	300	27	0.10	1	0.004
Minerals supplement	124	460	3.71*	97	0.79
Napier grass	19899	93528	4.70*	153532	0.77
Molasses	29	14	0.47	19	0.64
Maize stover	131	262	1.10	62	0.47
Accaricide/dipping	161	473	2.93*	85	0.53
Vaccination	3	2	0.77	6	1.94
Drugs/antihelminthics	128	162	1.27	32	0.25
Heifers	39500	12500	0.03	85000	2.15
Cows	6525	4500	0.74	32358	5.28
AI	70	240	3.43*	16	0.24
Bull service	6	32	5.19*	6	0.96
Dairy labour	20436	114782	5.62*	21250	1.04
Total dairying expenditure	93268	407282	4.37*	42895	0.46
Grade dairy cattle output value/cow/year					
Milk	170092	371001	2.18	216305	1.27
Heifers	35221	80392	2.28	70534	2.00
Female calves	5360	15759	2.94	7915	1.48
Young bulls	12971	30535	2.35	41939	3.23
Culls	59091	65491	1.11	22433	0.38
Manure	338	704	2.08	161	0.48
Total output value	492000	2098775	4.27*	201024	0.41
Gross margin	98432	107935	1.10	166110	1.69

* Means significantly different ($P<0.05$)

Table 5.2. Means and standard errors of expenditure on inputs and output value (KES) for the grade dairy cattle sub system under the different grade dairy cattle production systems.

Parameter	Grazing only	Mainly grazing + some stall feeding	Mainly stall feeding + some grazing	Stall feeding only
Expenditure/cow/year				
Dairy meal	$1691^{a} \pm 282$	$1917^{a} \pm 212$	$3552^{b} \pm 330$	$3525^{b} \pm 298$
Hay/straw	-	-	-	583 ± 159
Minerals supplement	$291^{a} \pm 36$	$375^{ab} \pm 50$	$523^{b} \pm 37$	$515^{b} \pm 44$
Napier grass	$2375^{a} \pm 537$	$2968^{a} \pm 480$	$4099^{ab} \pm 446$	$6415^{b} \pm 690$
Molasses	-	-	233 ± 51	322 ± 64
Maize stover	$1250^{b} \pm 50$	$876^{ab} \pm 84$	$687^{a} \pm 100$	$614^{a} \pm 68$
Accaricide/dipping	$434^{a} \pm 54$	$512^{ab} \pm 47$	$694^{b} \pm 42$	$693^{b} \pm 48$
Vaccination	-	94 ± 12	130 ± 14	108 ± 10
Drugs/antihelminthics	649 ± 88	482 ± 48	603 ± 56	505 ± 33
AI	455 ± 94	418 ± 61	540 ± 65	420 ± 34
Bull service	186 ± 25	226 ± 10	191 ± 10	160 ± 8
Dairy labour	$5400^{a} \pm 755$	$6200^{a} \pm 580$	$10948^{b} \pm 1192$	$8471^{ab} \pm 574$
Total dairying expenditure	$9943^{a} \pm 1163$	$15031^{ab} \pm 1275$	$20571^{b} \pm 1325$	$25403^{b} \pm 1104$
Revenue (Output value)/cow/year				
Milk	$37378^{a} \pm 1770$	$39290^{ab} \pm 3157$	$35152^{b} \pm 871$	$44432^{ab} \pm 2343$
Heifers	-	8600 ± 510	14360 ± 2969	11636 ± 2391
Female calves	-	4333 ± 601	6300 ± 943	6867 ± 1435
Young bulls	-	-	8300 ± 850	10777 ± 1543
Culls	-	10500 ± 3500	9083 ± 1307	17300 ± 2809
Manure	-	1086 ± 97	1106 ± 145	735 ± 125
Total output value	$39628^{a} \pm 2458$	$41928^{ab} \pm 3320$	$38118^{b} \pm 2052$	$48630^{ab} \pm 2472$
Gross margin	28404 ± 2664	26897 ± 3356	17547 ± 1915	23226 ± 2236
Cash output-input ratio	4.0	3.0	2.0	2.0

* Means with different letters in a row were significantly different ($P<0.05$)

5.3.2 Output value from the grade dairy cattle sub system

Grade dairy cattle breed types had little influence ($P>0.05$) on the output value from the grade dairy cattle sub system (Table 5.1). However, total output value per cow per year (KES) to grade dairy cattle owning households from grade dairy cattle in general and from milk were significantly influenced ($P<0.05$) by the production system. Output value was higher in Stall feeding only production systems as opposed to the other grade dairy cattle production systems. As indicated in Table 5.2, output value from grade dairy cattle in general and from milk in Mainly stall feeding with some grazing production system was highest at KES 48630.0 and 44432.0 respectively.

Grade dairy cattle off-take (heifers, female calves, young bulls and culls) and sale of manure was not dependant ($P>0.05$) on either the grade dairy production system or breed type and the differences in gross margin were not significant ($P>0.05$) across production systems and breed types (Table 5.1). The cash output – input ratios in the four grade dairy cattle production systems were above 2.0 (Table 5.2), implying that irrespective of the grade dairy cattle production system, grade dairy cattle owning households received KES 2 and above for every KES 1 invested in the grade dairy cattle sub system. However, cash output-input ratios and gross margins were higher in Grazing only and Mainly grazing with some stall feeding as are low input systems. These positive returns from the grade dairy cattle sub system suggested a solid base for profitable grade dairy cattle production by mixed small scale farmers under the different grade dairy cattle production systems.

5.3.3 Expenditure on inputs in the crops sub-system

Grade dairy cattle production systems and breed types had little influence ($P>0.05$) on expenditure incurred by grade dairy cattle owning households on inputs for crop production (Table 5.3). Expenditure on inputs into tea production (labour and fertilizer) was slightly higher though not statistically (P>0.05) in the intensive grade dairy cattle production systems than in the extensive production systems (Table 5.4). This may be explained by the fact that in intensive grade dairy cattle production systems, there was more output value from the grade dairy cattle sub system resulting into more surplus cash to be injected into tea production, similar to findings by Salasya (2005). Expenditure on inputs for production of other crops under the different grade dairy cattle production systems was similar (P>0.05).

5.3.4 Output value from the crops sub system

Grade dairy cattle production systems significantly influenced (P<0.05) the output value from tea and less (P>0.05) the other crops (Table 5.3). Revenue from tea in the Stall feeding only production system was highest at KES 23521.3, while in Grazing only production system was lowest at KES 12392.0 (Table 4). Grade dairy cattle breed types had little influence (P>0.05) on the output value from the crops sub system (Table 5.3). Total output value and gross margin from the crops sub system was not affected (P>0.05) by grade dairy cattle production systems. Tea provided more revenue within the crops sub system for these grade dairy cattle owning households under the different grade dairy cattle production systems (Table 5.4). The cash output – input ratios for the crops sub system under the different grade dairy cattle production systems were similar but above 2.0, implying that grade dairy cattle owning households received KES 2 for every KES 1 invested in the crops sub system.

Table 5.3. Summary ANOVA for influence of grade dairy cattle production systems and breed types on expenditure on inputs and output value per household per year from the crops sub system in Vihiga.

Parameter	EMS ('000)	Production systems		Breed type	
		MS ('000)	F value	MS ('000)	F value
Expenditure on crops inputs/household/year					
Maize seed	531	520	0.98	288	0.54
Bean seed	214	151	0.71	198	0.93
DAP fertilizer	491	523	1.07	621	1.26
CAN fertilizer	541	437	0.81	353	0.65
Manure	205	3646	17.79*	106	0.52
Land preparation	1583	378	0.24	1631	1.03
Tea production inputs	6368	15392	2.42	5273	0.83
Total crops expenditure	21282	64769	3.04*	3652	0.17
Crops output value/household/year					
Tea income	67315	369125	5.48*	63132	0.94
Horticultural crops	4678	2095	0.45	5637	1.21
Maize	45339	448379	0.99	53263	1.18
Beans	6034	701	0.12	7263	1.20
Vegetables	588	1002	1.71	1089	1.85
Total crops output value	136918	284364	2.08	95218	0.70
Gross margin	73396	138789	1.89	71365	0.97

* Means significantly different (P<0.05)

Table 5.4. Means and standard errors of expenditure on inputs and output value (KES) for the crops sub system under the different grade dairy cattle production systems.

Parameter	Grazing only	Mainly grazing + some stall feeding	Mainly stall feeding + some grazing	Stall feeding only
Expenditure/household/year				
Maize seed	960 ± 91	1270 ± 139	982 ± 88	1025 ± 81
Bean seed	660 ± 87	729 ± 102	713 ± 59	812 ± 93
DAP fertilizer	1141 ± 204	1180 ± 117	987 ± 80	1245 ± 92
CAN fertilizer	1170 ± 93	1115 ± 145	1014 ± 101	1336 ± 132
Manure	1112^{a} ± 143	1545^{a} ± 126	1120^{a} ± 91	2168^{b} ± 110
Land preparation	1871 ± 280	1853± 221	1729 ± 155	1868 ± 147
Tea production inputs	4000 ± 1091	5417 ± 450	4500 ± 398	6378 ± 526
Total crops expenditure	8299 ± 199	11668 ± 624	9601 ± 840	12423 ± 790
Revenue (Output value)/household/year				
Tea income	12392^{a} ± 2549	17134^{ab} ± 13301	15157^{ab} ± 1336	23521^{b} ± 1774
Horticultural crops	2889 ± 250	3707 ± 618	3073 ± 513	2497 ± 308
Maize	8812 ± 1421	5393 ± 912	7044 ± 740	7836 ± 979
Beans	3150 ± 429	3097 ± 424	3123 ± 355	2943 ± 347
Vegetables	1800	1349 ± 201	1249 ± 136	1591 ± 149
Total crops output value	16522^{a} ± 1084	23513^{ab} ± 1084	20089^{ab} ± 1479	31991^{b} ± 1899
Gross margin	8223 ± 1001	11845 ± 1074	10489 ± 1266	19568 ± 1733
Cash output-input ratio	2.0	2.0	2.1	2.5

* Means with different letters in a row were significantly different (P<0.05)

5.4 CONCLUSION

There was surplus of output value over expenditure on inputs for both the grade dairy cattle and crops sub systems, an indication that farmers were making profit across the different grade dairy cattle production systems in Vihiga. In general, there was more surplus from the grade dairy cattle sub system than from the crops sub system across the different grade dairy cattle production systems. The grade dairy cattle sub system contributed about 70% (KES 21937.33 per cow per year) to the incomes of the small scale mixed grade dairy cattle owning households and the crops sub system contributed 30% (KES 9204.5 per household per year), though the cash output-input ratios for the two sub systems were similar.

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Chapter 6

6.0 GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATIONS

6.1 GENERAL DISCUSSION

The first objective was to characterize grade dairy cattle owning households under four grade dairy cattle production systems in Vihiga. General household characteristics under the four production systems were consistent with those of other areas in the Kenya highlands. Land sizes were small, averaging 2.27 acres (Chapter 3) due to continuous sub divisions. The farm system was mixed, with farmers growing a multiplicity of crops mainly for subsistence, a strategy aimed at spreading risks and maximising profits. Livestock of various kinds were reared with grade dairy cattle and local poultry being the most important. Maize and beans was the most important food crop combination grown on an average of 0.76 acres, followed by tea the main cash crop (0.58 acres). Napier grass, the basal feed resource for grade dairy cattle was grown on an average 0.54 acres.

Food security was the primary objective for dairying, followed by income generation through marketing of surplus milk (Chapter 3). The main expenditures of farm income were on food and school fees. Grade dairy cattle production systems were mainly (80%) intensive (Stall feeding only and Mainly stall feeding with some grazing). The grade dairy cattle herd comprised mainly Ayrshire cross (33.1%), Holstein-Friesian cross (30.5%) and Holstein-Friesian pure (13.6%). Grade dairy cows had late age at first calving and long calving intervals. However, these were affected by the grade dairy cattle production systems and were slightly lower in Stall feeding only as compared to Grazing only. Calving interval and age at first calving were similar for the different breed types.

Milk production/cow/day was low, averaging about 5.49 litres or 1674.45 litres/305 day lactation period (Chapter 3). Milk production levels/cow/day were not significantly different amongst the grade dairy cattle breed types and production systems. Grade dairy cattle owning households did not realise higher milk yield when using the larger dairy breeds with higher potential for milk yield than when using smaller dairy breeds with lower potential for milk yield. Also contrary to expectations, milk yields in intensive systems (Stall feeding only and Mainly stall feeding with some grazing) were similar to extensive systems (Grazing only and Mainly grazing with some stall feeding). Low milk production levels were a result of low access to limited resources (land and capital) by these smallholders and minimal investment in appropriate grade dairy cattle feeding strategies and practices (Chapter 4).

The second objective was to model the influence of existing feeding strategies on performance of grade dairy cattle under four production systems in Vihiga. Inadequate feed (quality and quantity) was the major limiting factor to bio-economic performance of grade dairy cattle. In response, grade dairy cattle owning households opted to keep fewer animals (mean 3.55) with relatively higher output value, but with less investment in feeding (Chapters 3, 4 and 5). Further, households had reduced competition for the available feeds by reducing the proportion of heifers and males relative to dairy cows in their herds, where herds comprised 45.02% cows. Land size, availability of feed and affordable human labour had a major influence on the grade dairy cattle herd size. Reduction in herd size to match the available feed resources was found to be a viable option unless farmers kept only one cow.

For feeding their herds, grade dairy cattle owning households had increased their own production of fodder (particularly napier grass, the basal feed resource) and purchase of feeds (Chapter 3 and 5). Availability of feed from napier grass and natural pastures was, however, limited in quantities due to land scarcity and required supplementation. Protein rich fodder, crop residues and agro-industrial by products were used as supplements, but their use was also limited by availability, variability in quantity and quality and costs. Grade dairy cattle feed resources of an individual household were therefore also supplemented by sources from outside the farm (Chapter 5).

Simulation analysis using the Dairy simulation Model showed that generally feeding strategies for grade dairy cattle were sub-optimal in meeting the DM requirements of the grade dairy cattle (Chapter 4). Crossbred cows (Ayrshire/Brown Swiss x Sahiwal) when fed on napier grass only will consume about 2.2 kg dry matter of napier grass per 100 kg body weight. This will provide enough nutrients for their maintenance and about 5kg of milk. Cows fed on napier grass and supplemented with about 8 kg of fresh leucaena (2 kg dry matter) will consume about 2.8 kg dry matter per 100 kg body weight. This fodder mixture will provide enough nutrients for maintenance and about 10 kg of milk daily. A crossbred cow weighing about 400 kg at peak milk production should be offered about 12 kg of dry matter per day. For the cow to produce 15 kg of milk per day, it should have feed available at all times. From these foregoing scenarios, it is clear that grade dairy cows in Vihiga were underfed and this was reflected in low milk production per cow per day and per 305 day lactation period (Chapters 3 and 4). The cows thus failed to reach their full genetic potential (Chapter 4).

Results of this study also indicated that milk production did not vary by breed (Chapter 3 and 5) or grade dairy cattle production system with the existing feeding strategies (Chapter 4). Actual milk production was lower than potential milk production with all the existing feeding strategies under the four production systems (Chapter 4). However, actual milk production was far much lower with the basic than optimal existing feeding strategies. Actual milk production and hence economic returns from grade dairy cows was influenced by the distribution of feed availability throughout the year. Vihiga had less feed availability especially during the dry season, leading farmers to supplement with crop residues (maize stover, banana pseudo stems etc) of low nutritional quality and agro-industrial by products (molasses, brewers waste, wheat bran, cotton seed cake, maize bran etc) that were costly.

The gap between actual and potential milk production per 305 day lactation period was in excess of about 1670 kg with existing basic feeding strategies and about 700 kg with existing optimal feeding strategies in the four grade dairy cattle production systems. Gross margins per cow in the four production systems were low which was explained by inappropriate feeding strategies resulting into the animals not reaching their milk production potential. Most of the feed consisted napier grass and natural pastures with minimal supplementation (Chapter 4). Methane emissions per cow per year were lower with basic diets without supplementation in all production systems.

The third objective was to analyze expenditure on inputs and output value from both the grade dairy cattle and crops sub systems in Vihiga. Total expenditure on inputs and total output value from the grade dairy cattle sub system and tea for the crops sub system were significantly influenced ($P<0.05$) by the grade dairy cattle production system (Chapter 5). These were higher in intensive production systems (Stall feeding only and Mainly stall feeding with some grazing) than in extensive systems (Grazing only and Mainly grazing with some stall feeding). Gross margins for the grade dairy cattle sub system, though not significantly ($P>0.05$) influenced by production systems, were slightly higher in Grazing only (KES 28404.0) compared to Mainly stall feeding with some grazing production system (KES 17547.0). Generally, there was surplus of output value over expenditure on inputs from grade dairy cattle and crop sub systems, an indication that farmers were making profit across the four production systems (Chapter 5).

There was more surplus from grade dairy cattle than from all crop activities. Cash output-input ratios were similar for both the crops and grade dairy cattle sub systems of 2.0 and above, suggesting a return of about KES 2 for every shilling invested (Chapter 5). It is important to note that despite the fact that surplus from grade dairy cattle was higher than from the tea crop, farmers were not specializing on dairy cattle production. It is possible to assume that these enterprises were complimentary, even with land as a shared resource, such that income from one enterprise was used to boost the other. A farmer could utilize sales from tea to buy a dairy animal or sale milk to buy fertilizer or pay labour for tea production. Also since the main farming objective of the grade dairy cattle owning households was improving food security (Chapter 3), incomes from both enterprises were used to boost food crop production through purchase of seed and fertilizer and paying casual/hired labour.

Similarity in cash input-output (cost-benefit) ratios for the two sub systems (Chapter 5) implies that farmers in Vihiga were making profit from both sub systems. However, higher economic returns from the grade dairy cattle sub system as opposed to the crops sub system implied a solid base for profitable dairy production under the four grade dairy cattle production systems. Integration of crops (food and cash) with grade dairy cattle production provided grade dairy cattle owning households with an opportunity to reduce risks inherent in production from a single crop or livestock enterprise, a strategy crucial to food security and poverty alleviation.

6.2 CONCLUSION

From this study, we can conclude that:

- Because of the need to satisfy households' requirements for food and incomes, grade dairy cattle owning households had adopted more of the intensive grade dairy cattle production systems (Stall feeding only and Mainly stall feeding with some grazing).
- Since food supply was the major objective of farming, it implies that farming in the area was mainly for subsistence and there was no specialization. In general households considered income generation their second most important objective in farming after provision of food.
- Production and calving performance parameters for grade dairy cattle were low, limiting optimization of productivity under the four grade dairy cattle production systems. These

reflected low levels of feeding. Feeding strategies were characterized by use of low-quality bulky feeds with less risk in terms of investment requirements.

- Existing feeding strategies for grade dairy cattle were sub-optimal, failing to realize the full economic and production potential of grade dairy cattle, and thereby not taking advantage of the cows' biological potential.
- Inadequate protein nutrition was a major limiting factor to performance of grade dairy cattle in Vihiga and the situation was serious especially during the dry season when low quality forages (3-7% CP) like maize stover and other crop residues were offered.
- From simulation analysis, the costs of milk production, gross margins from milk/cow/year and manure production were higher in intensive production systems compared to the extensive production systems.
- Costs of milk production and economic returns were higher from existing feeding strategies utilized in intensive production systems as opposed to the extensive production systems.
- Simulated results indicated the most optimum existing feeding strategies for Vihiga in terms of economic returns by grade dairy cattle production systems as: a) napier grass supplemented dairy meal and fodder in Stall feeding only and Grazing only production systems, and b) natural pastures and napier grass supplemented dairy meal, fodder and crop residue in Mainly stall feeding with some grazing and Mainly grazing with some stall feeding production systems.
- There was surplus of output value over expenditure on inputs for both the grade dairy cattle and crops sub systems, an indication that farmers were making profit across the four grade dairy cattle production systems. Importantly, there was more surplus from the grade dairy cattle sub system than from the crops sub system.

6.3 RECOMMENDATIONS

This study recommends that:

- In order to realize economically viable milk production form grade dairy cattle in Vihiga, supplementation of the basal diets with dairy meal and protein rich fodder (e.g. sweet potato vines and fodder legumes/trees) as single supplements or components in compound feeding strategies is necessary.
- The grade dairy cattle resource base in Vihiga is narrow and need expansion. Appropriate dairy cattle breeds in terms of body size and milk yield, preferably medium sized channel island dairy cattle pure or cross breeds are necessary. In this case, the available feed resources will be matched with the dairy cattle breed types.
- Although dairy meal, protein rich fodder (sweet potato vines and fodder trees/legumes) are available and able to meet part of the DM requirements, an additional source of high energy-high protein should be sought. Forage/fodder and legume mixture rich in water soluble carbohydrates should be identified and utilized. Hence it would be important to consider intercropping napier grass, Columbus grass and forage sorghum with desmodium, stylosanthes, calliandra, leucaena, sesbania sesban, dual purpose sweet potatos and dolichos lab lab.

APPENDIX 1

BIO-ECONOMIC PERFORMANCE EVALUATION QUESTIONNAIRE

MARCH 2005

Questionnaire Identification

(To be filled by supervisor at time of issuing questionnaire

Enumerator Name [________________

Questionnaire Serial No: [__________

Date: [______________________]

Farmer Name: ____

Division: ____

Location:____

Sub Location: _________________________________

Village: ______________________________________

AGRO-ECOLOGICAL ZONE: ______________________________

Name of the respondent: [________________________________]

Relationship to the HH: (Use codes below) [___] [___]

DECISION MAKING

Who is the **decision maker** in relation to grade dairy **cattle breeding** and management? (Use codes below) [____]

Codes for decision maker

1=Husband

2=Son

3=House help/ farm labourer 7=Hired mar

4=None

Try to interview the decision maker if possible. Are you interviewing the decision maker? YES [____ [____]

Indicate ethnic group of Household [_______________]

Codes for ethnic affiliation

1 = Nandi

2 = Tiriki

3 = Luo

4 = Maragoli

5 = Banyore

6= Other (specify)_________

Does the household keep grade dairy cattle breeds (Friesian, Jersey, Ayrshire, Guernsey) *and* crossbreeds or upgrades)?

YES [____]

NO [____]

Only households keeping grade dairy cattle should be interviewed.

SECTION A: HOUSEHOLD AND FARM SYSTEM CHARACTERISATION

1. Give details of all household members (**including the HH head**) living permanently on the compound and their primary activities and/or occupations (**on and off farm**): Please fill in the first row the characteristics of the household head.

BE SURE THAT ALL CHILDREN AND INFANTS ARE INCLUDED

Name (first name only)	R/ship to HH head	Year of Birth	Sex 1= M 2 = F	Highest education level completed (Code)	Primary Activities AND/OR Occupations
1	[___]		[___]	[___]	[___] [___]
2	[___]		[___]	[___]	[___] [___]
3	[___]		[___]	[___]	[___] [___]
4	[___]		[___]	[___]	[___] [___]
5	[___]		[___]	[___]	[___] [___]
6	[___]		[___]	[___]	[___] [___]
7	[___]		[___]	[___]	[___] [___]
8	[___]		[___]	[___]	[___] [___]
9	[___]		[___]	[___]	[___] [___]
10	[___]		[___]	[___]	[___] [___]
11	[___]		[___]	[___]	[___] [___]
12	[___]		[___]	[___]	[___] [___]
13	[___]		[___]	[___]	[___] [___]
14	[___]		[___]	[___]	[___] [___]

NB* A person is in residence if s/he sleeps in the house a majority of nights per week.

(Refer to Codes Next Page for the above section)

Relationship to the HHH	**Education Level**	**Activities and occupations**
1=Household head	0 = No formal education	0 = None
2=Wife to household head	1 = Standard 1 through 4	1 = Farm management/farmer
3=Hired manager	2 = Standard 5 through 8	2 = Civil servant
4=Herdsman	3 = Form 1 or 2	3 = Employee in private enterprise
5=Son	4 = Form 3 or 4	4 = Businessman
6=Daughter	5 = Post secondary school ('A' level)	5 = Labourer on farm
7=Husband	6 = Technical college (diploma or certificate)	6 = Labourer off farm
8=Other (Specify)	7 = Adult literacy education	7 = Retired with pension
	8 = University	8 = Retired without pension
	9 = Other (specify)_________	9 = Religious leader
		10 = in school/college
		11 = Pre-school age
		12 = Other (specify)

2. Who is the farm owner? [____]

3. Who is the farm manager? [____]

4. Highest level of education of farm manager [____] [**Use codes above**]

Codes for farm owner/Manager	
1=Husband	
2=Son	
3=farm labourer	7=Hired manager
4=None	

Land size and Ownership

5. What is the total size of land **currently possessed in acres**? [___ ___.___]

6. Which crops do you currently grow on your farm and acreage

Food Crops	Acreage	Cash Crops	Acreage	Pastures and Fodder crops	Acreage
1 Maize	[___]	15 Tea	[___]	23 Desmodium	[___]
2 Beans	[___]	16 Coffee	[___]	24 Fallow and natural pasture	[___]
3 Sorghum/finger millet	[___]	17 Sugar cane (sugar)	[___]	25 Napier grass	[___]
4 Bananas	[___]	18 Sugar cane (juice)	[___]	26 Planted pasture i.e. Rhodes	[___]
5 Kales (sukuma wiki)	[___]	19 Sim sim	[___]	27 thatch grass	[___]
6 Sweet potatoes	[___]	20 ground nuts	[___]	28 Lucerne	[___]
7 Cow peas	[___]	21 fruit/tree crops	[___]	30 Fodder trees	[___]
8 Cassava	[___]	22 other	[___]	calliandra	[___]
9 onions/tomatoes	[___]		[___]	Sesbania sesban	[___]
10 Pigeon peas	[___]		[___]	Leucaena	[___]
11 Cabbage/carrots	[___]		[___]	Gliricidia	[___]
12 paw paw	[___]		[___]	31 other	[___]
13Local vegetables	[___]		[___]		[___]
14 other	[___]		[___]		[___]

SECTION B: FARMING AND DAIRY PRODUCTION OBJECTIVES

1. When did you start dairy cattle farming? [Give Year] [__ __ __ __]
2. Number of years of livestock farming experience [_________] [**NB Farmer may have had experience elsewhere prior to establishing own farm]**
3. What are your **main objectives** in **farming**?

OBJECTIVE	**Rank**
Food supply	[______]
Basic income / profit	[______]
Maximise profits	[______]
Conservation of soils and soil fertility	[______]
Social prestige and status	[______]
Other (specify) _______________	[______]

4. What are your **main objectives** in dairying?

Objective	Rank
Surplus milk for sale	[_____]
Milk for home consumption	[_____]
Manure for sale	[_____]
Breeding stock for sale	[_____]
Capital assets building	[_____]
Supplement income sources	[_____]
Other (specify) ______________	[_____]

5. Does the household or farm have the following amenities **(currently working)**: **(tick appropriate)**

Electricity supply [___]=YES [___]=NO

A **telephone** connection (Mobile or Landline) [___]=YES [___]=NO

Piped public water supply [___]=YES [___]=NO

6. Which of the following **means of transportation** does the household or farm have? [___]=NONE (tick)

List: Item 1 [___] Item 2 [___] Item 3 [___] Item 4 [___]

Codes for means of transport	
1 = Bicycle	6 = Tractor
2 = Wheelbarrow	7 = Pick-up
3 = Handcart	8 = Car
4 = Animal drawn cart	9 = Other specify__________________
5 = Motorcycle	

7. How **far** is the household **from** (in **kilometres**);

   A road open to vehicles all year [___ ___ .___] Km

   A roadpassable only during the dry season [___ ___ .___] Km

   The closest market or trading centre [___ ___ .___] Km

8. Do you currently employ any long-term labourers**?** [___] = YES [___]= NO

   If yes what wage per month

   Ksh _________ Lodging and meals provided 1=Yes 2=No

9. Do you currently employ any casual labourers**?** [___] = YES [___]= NO

   If yes what wage per day Ksh _________ Meals provided 1=Yes 2=No

Farm enterprises and Income estimates

10. **Rank the following enterprises in terms of income generated**

General	Importance ranking for an average year
Farm income	[______]
Off-farm income (employment, business, etc.)	[______]
Remittances	[______]
Other source Specify__________	[______]

11. **For FARM INCOME Rank the following sources** of farm income

Farm Income	Importance ranking for an average year
Dairy cattle sale of milk	[_____]
Dairy cattle sale of animals	[_____]
Other livestock products	[_____]
Cash Crops	[_____]
Food Crops	[_____]
Horticultural Crops	[_____]
Others (Specify)	[_____]

13. Rank your main types of expenditures in terms of largest per year.

For ranking: 1 = largest expenditure; 2 = 2nd; 3 = 3rd; etc.

Expenditure	Importance ranking for an average year
Food	[_____]
School fees	[_____]
Other livestock products	[_____]
Fertilizer	[_____]
Dairy cattle feeds and drugs	[_____]
Family health costs	[_____]
Others (Specify)	[_____]

14. Livestock inventory: indicate the numbers of animals for the different species kept on the farm (**except grade dairy cattle**)

	Number owned by the household	Number kept but not owned
Zebu cattle	[___]	[___]
Goats		
Local goats	[___]	[___]
Dairy goats (male)	[___]	[___]
Dairy goats (female)	[___]	
Sheep	[___]	[___]
Poultry		
Local chicken	[___]	[___]
Layers (exotic)	[___]	[___]
Broilers (exotic)	[___]	[___]
Pigs	[___]	[___]
Rabbits	[___]	[___]
Bee hives (traditional)	[___]	[___]
Bee hives (improved)	[___]	[___]

SECTION C: FEEDING SYSTEM

1. What is your **main system for keeping cattle** now and what was it 10 years ago, if established then?

	Presently	10 years ago (skip if farm less than 10 yrs)
Dairy cattle	[___]	[___]
Zebu cattle	[___]	[___]

Main system for keeping cattle

1 = Only grazing (free-range or tethered)

2 = Mainly grazing with some stall feeding

3 = Mainly stall feeding with some grazing

4 = Only stall feeding (zero grazing)

2. Do you **REGULARLY** (**Every year**) experience a shortage of feeds? [___]=YES [___]=NO (tick)

   a. If Yes, when? Indicate the corresponding season and **tick** those when feed shortages are greatest.

   Dry season [___]

   Rainy season [___]

   All year round (Any time) [___]

Tick the major coping strategies (in terms of importance) you apply during these periods of feed shortages

Coping Strategy during Feed Shortages	Rank coping strategy in terms of importance
Use standing mature fodder (Napier or other)	[___]
Use cut and stored forages (Stover, hay, other crop residues, et. – NOT Purchased	
Feed less to all animals	[___]
Feed less to certain categories of animals	[___]
Feed silage (specify forage type____)	
Rent grazing land	[___]
Take cattle to search for pasture elsewhere	
Reduce herd size	[___]
Purchase fodder	[___]
Purchase concentrate feed	[___]
Feed tree leaves/forage not normally used	[___]
Other (specify)	[___]

3. Water

   a. Is water always available to your animals throughout the day? [___]=YES [___]=NO (tick)

   If **No**, how **frequently do you water** your cows? [___]

1= Once a day	3= Three times a day
2= Twice a day	4= Other (specify) __________

   b. What is the **source of this water?** [___][___] (code)

1= Carted to farm	4 = Piped public water supply
2= On-farm well / bore hole	5 = Closest river/stream ___________________
3 = Rain catchments	6 = Other (specify)________________________

   c. If you have to collect water what is the distance to the source? [__ __.__] (Kms.)

4. a) Which is the basal feed resource for your dairy cattle and what quantity do you give?

____

____

b) What other feed supplements do you give to your dairy cattle and their quantities?

____

____

____

____

____

SECTION D. GRADE DAIRY CATTLE HERD STRUCTURE, BREEDING AND MANAGEMENT DECISIONS

1. Give a detailed grade dairy cattle herd structure by filling in the table

Animals kept by category of animal	Breeds				
	[__ __]	[__ __]	[__ __]	[__ __]	[__ __]
	Number	Number	Number	Number	Number
Bulls (> 3 yrs)	[__ __]	[__ __]	[__ __]	[__ __]	[__ __]
Castrated adult males (oxen, >3 yrs)	[__ __]	[__ __]	[__ __]	[__ __]	[__ __]
Immature males (<3 yrs)	[__ __]	[__ __]	[__ __]	[__ __]	[__ __]
Cows (calved at least once)	[__ __]	[__ __]	[__ __]	[__ __]	[__ __]
Heifers (post-weaned, pre calving)	[__ __]	[__ __]	[__ __]	[__ __]	[__ __]
Pre-weaning males	[__ __]	[__ __]	[__ __]	[__ __]	[__ __]
Pre-weaning females	[__ __]	[__ __]	[__ __]	[__ __]	[__ __]
Total	[__ __]	[__ __]	[__ __]	[__ __]	[__ __]

N.B. If cross, indicate a maximum of 2 breeds, e.g. Friesian*Zebu is coded as [2 11]

Breed codes

1. = Holstein-Friesian (pure) 4. = Ayrshire (cross) 7.
= Guernsey (pure) 10. = Boran
13= other, specify
2. = Holstein-Friesian (cross) 5. = Jersey (pure)
8. = Guernsey (cross) 11. = Local Zebu
____
3. = Ayrshire (pure) 6.
= Jersey (cross) 9.
= Sahiwal 12.
= Undefined

2. How did you get your first **grade dairy cow**? [_____]
   If **purchased**, why not reared on farm? [____]
   If **reared on farm**, why not purchased? [_____]……..
3. Which were the foundation/starting breed(s) (use codes question 1)? [___] [___] [___]
4. What was the source of the foundation breeds? [____] [____] [____]
5. Did you **choose** the breeds you currently have? YES [____] NO [____]
6. If yes, how did you get to know about the breeds? [_____] [_____] [_____]
7. What qualities of the breeds interested you? [_____] [_____] [_____]

Source: first cow/first breeds/foundation stock	Why Not Reared	Why Not Purchased	How you got to know about the breeds	Qualities of breeds that interested you
1. = Inherited/Gift	1=High mortalities	1=Too costly to buy	1. Advice from the AI service provider	1. High milk yield
2. = Project support (Govt, NGO, COOP, Self Help Groups)	2=Lack of capital	2=Good mature animals not available in the market	2.Historical reasons/ experience	2. High disease resistance
3. = Bought from large-scale private dairy farm	3=Easily available	3=Lack of capital	3. Everybody around keeps those breeds	3. Big body size
4. = Bought from Government farm	4=Present stock is of poor quality	4=Required breed not easily available	4. Inheritance/gifts	4. Low feed intake
5. = Bought from smallholder farm	5=No AI/Grade bulls in the area	5=Other reason specify________	5. Literature/media	5. High fertility
6 = Bought from cattle market	6=Infertility		6. Extension advice	6. Drought tolerance
7. = Bought from individual farm or trader	7= Other specify________		7. Other source of info specify [_________]	7. Traction ability
8. = Loan from project				8. Milk quality (% butter fat)
9. = Obtained as dowry				9. High growth rates
10 =through borrowed/rented bull on heifer/cow				10. Coat color
11. = Upgrading of Zebus using AI (through AI on heifer/ cow)				11. Other quality specify [_________]
12. = Other (specify) _______________________				

8. What are the MAIN sources of replacement stock Please put the most important one first [___] [___] [___]

Source of replacement stock	
1=purchased from large-scale farmers	3=Upgrading of Zebus using AI
2=Purchase from small-scale farmers	4=Upgrading of Zebus using Bull Service
3= Purchase from local cattle market	5=Project support (Govt, NGO, COOP, Self H Groups)
4= Reared on farm	6= Other specify___________________

9. What is the MAIN fate of female calves: [___] [___] [___]

10. What is the MAIN fate of male calves: [___] [___] [___]

Fate of Calves		
1=Sold after weaning	2=Rear it on farm	3= Other specify ___________

11. Castration

a. For the Male calves retained on farm, do you castrate the male calves? [___] 1 = YES 2 = NO

b. If **yes**, why.[___ ____ ____]

WHY CASTRATING	
1= Control breeding	4= Better draft power
2= Improve meat quality	5= Better temperament
3= Fetch better price	6= Other specify ___________

c. At what age do you castrate MALE calves? [_____]

AGE CALVES ARE CASTRATED	
1= before 3 months	3= 6-12 months
2= 3 – 6 months	4= above 12 months

/12. a) What methods do you use to feed milk to your calves? [___][___] (Code)

1 = let it suckle all d 4 = Nipple feeding

2= Restrict suckling 5= Bottle feeding

3 = Bucket feeding

b) If you let them suckle, how long do they continue suckling? Give period in months [___][___)

c) How many times a day do you milk your cows per day? (Tick appropriate) 3 times (___) 2 times (___) Once (___)

d) At what age in months do you wean the calves (average of last 3 calves) Males (______) Females (_____)

e) If sold, at what age in months (average of last 3 calves) Males (______) Females (_____)

12. MILK PRODUCTION AND UTILIZATION

A) FOR EACH GRADE DAIRY COW IN THE HERD UP TO 3, FILL A ROW (IF NUMBER OF COWS ARE MORE THAN 3, THEN RANDOMLY SELECT 3, INCLUDING 1 ZEBU)

Cow Name	Breed (see codes)	Cow Age (Yrs)	Number of Calvings	Age at first calving (months)	Pregnant now 1 = Yes 2 = No	Source of last service (see codes)	Last service date MM/YR	Last calving date MM/YR	Second last calving date MM/YR	Date stopped milking MM/YR	Total Milk Production (morning plus evening milk) Milk Unit codes: [____]
	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]	[________]
	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]	[________]
	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]	[________]
	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]	[________]
	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]	[________]

SOURCE OF SERVICE

1 = Own bull
2 = Other farmers bull
3 = Government AI
4 = Private AI
5 = Coop/Self Help Group AI
6 = Project AI
7 = Project bull
8 = Unknown bull
9 = Other

Breed codes

1. = Holstein-Friesian (pure)
2. = Holstein-Friesian (cross)
3. = Ayrshire (pure)
4. = Ayrshire (cross)
5. = Jersey (pure)
6. = Jersey (cross)
7. = Guernsey (pure)
8. = Guernsey (cross)
9. = Sahiwal
10. = Boran
11. = Local Zebu
12. = Undefined
13= other, specify

MILK UNITS

1 = Litre
2 = Kg
3 = Grams
4 = Treetop bottle (750ml)
5 = "Pint" or large cup (500ml)
6 = Small cup (350gm)
7 = Other (specify)

b) Level of commercialisation: Milk utilization and disposal

Where milk is sold or used	**Quantity of Milk** **Milk units code [________]**
1 = Household consumption	[_____]
2= Calves consumption	[_____]
3 = Sold to neighbours	[_____]
4 = Dairy co-operative	[_____]
5= Hawkers	[_____]
6 = Others (specify)_____________	[_____]

12. DID YOU PURCHASE OR OBTAIN GRADE DAIRY CATTLE IN THE LAST 12 MONTHS? [___] 1 = YES 2 = NO (ANIMALS BORN ON FARM SHOULD NOT BE LISTED HERE)

a) If **YES**, fill in the table for dairy cattle purchased or otherwise obtained during the last 12 months

CATTLE PURCHASED OR OBTAINED (use separate row for each animal)									
Animal type	Breed	Age (Yrs)	State (for cow only)	Number of calvings	Season	From whom (source of animal)	From Where	Reasons for purchase	Cost (Kshs)
[____]	[____]	[____]	[____]	[____]	[____]	[____]	[____]	[____][____]	[_________]
[____]	[____]	[____]	[____]	[____]	[____]	[____]	[____]	[____][____]	[_________]
[____]	[____]	[____]	[____]	[____]	[____]	[____]	[____]	[____][____]	[_________]
[____]	[____]	[____]	[____]	[____]	[____]	[____]	[____]	[____][____]	[_________]
[____]	[____]	[____]	[____]	[____]	[____]	[____]	[____]	[____][____]	[_________]

ANIMAL TYPE

1 = Bulls (>3 yrs or used for service)
2 = Castrated adult males (>3 yrs)
3 = Immature males (< 3 yrs)
4 = Cows
5 = Heifers
6 = Pre-weaning males
7 = Pre-weaning females

Breed codes

1. = Holstein-Friesian (pure)
2. = Holstein-Friesian (cross)
3. = Ayrshire (pure)
4. = Ayrshire (cross)
5. = Jersey (pure)
6. = Jersey (cross)
7. = Guernsey (pure)
8. = Guernsey (cross)
9. = Sahiwal
10. = Boran
11. = Local Zebu
12. = Undefined
13= other, specify

State (cows only)

1 = Dry
2 = Pregnant
3 = Lactating

Season

1=Rainy Season
2 = Dry Season

FROM WHOM- SOURCE OF ANIMAL

1 = Reared on farm
2 = Kept but not owned
3 = Bought from large private dairy farm
4 = Bought from smallholder farm
5 = Bought from individual trader/broker
6 = Loan from project
7 =Gift from relatives/ others
8 = Obtained as dowry
9 = Other (specify)__________

FROM/ TO WHERE

1 = Within the sub-location
2 = Within the district
3 = Outside the district

Reasons for Purchase

1 = Replacement of old animal
2 = Obtain more manure
3 = Increase social prestige
4 = Increased milk production
5 = Other (specify)_________

b) What information is asked from the sellers when buying animals [___] [___][___] [___]? (see codes below)

c) Do you ask about parentage when buying? YES [__] NO [__] and if NOT, Why NOT? [___]

Codes for question 12 b) and 13 b)	**Codes for question 12 c)**
Info received or given when buying/selling	**Codes for Why NOT ask about parentage**
1=Breeding history	1=Not interested/ not important
2=Parentage records	2=Never thought about it
3=Age of animal	3=Parentage details are not usually available
4=Production records	4=I don't know what is parentage
5=Health information	5=Other reasons Specify_______________________________
6=Reason(s) for selling	6=Other reasons Specify_______________________________
7=Others Specify_________	

13. DID YOU **SELL OR SLAUGHTER GRADE DAIRY** CATTLE IN THE LAST 12 MONTHS? [___] 1 = YES 2 = NO

A)IF YES, **FILL IN THE TABLE FOR CATTLE SOLD OR SLAUGHTERED DURING THE LAST 12 MONTHS**

CATTLE SOLD or SLAUGHTERED (separate row for each animal) Use the codes below										
Animal type	Breed	Age (Yrs)	State (for cow only)	Number of calvings *	Season	Source of animal	Where sold	Reason for sale or slaughter	Sold to whom	Price Received (Kshs)
[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]	[___]	
[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]	[___]	
[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]	[___]	
[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]	[___]	
[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]	[___]	

b) What information is given to buyers when selling animals [___] [___][___] [___]?

14. HAS ANY CATTLE DIED OR WERE STOLEN IN THE LAST 12 MONTHS? [___] 1 = YES 2 = NO

IF YES, **FILL IN THE TABLE FOR CATTLE WHICH DIED OR WERE STOLEN DURING THE LAST 12 MONTHS**

CATTLE that DIED or were STOLEN (separate row for each animal)							
Animal type	Breed	Age (Yrs)	State (for cow only)	Number of calvings	Season	Source of animal	Cause of death/loss
[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]
[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]
[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]
[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]
[___]	[___]	[___]	[___]	[___]	[___]	[___]	[___][___]

Common codes for question 13 and 14

CODES FOR QUESTION 13

Reason for selling or slaughtering

1 = For cash or income
2 = Old age
3 = Disease
4 = Poor performance
5 = Slaughtered for meat
6 = Unwanted (e.g. bull calves)
7 = Ritual / ceremony
8 = Other__________

Sold to whom

1 = Individual
2 = Butcher
3 = Broker/ trader
4 = Other (specify)_________

CODES FOR QUESTION 14

Cause of death or loss

1 = Old age /natural death
2 = Died due to disease
3 = Died due to injury, accidents
4 = Died due to poisoning (acaricide, snake bite, bracken fern, etc)
5 = Died due to bloat
6 = Died due to starvation
7 = Stolen
8 = Neglect (eg bull calves)
9 = Other _______________

SECTION E: BREEDING SERVICES

1. Mating methods

ing method most commonly used NOW for first service	ing method most commonly used 10 years ago	t preferred mating method for first service	if same method is used for repeats	son(s) for preferred mating. If more than 1, please rank
[___]	[___]	[___]	[___]	[___] [___] [___]
[___]	[___]	[___]	[___]	[___] [___] [___]
[___]	[___]	[___]	[___]	[___] [___] [___]
[___]	[___]	[___]	[___]	[___] [___] [___]
[___]	[___]	[___]	[___]	[___] [___] [___]

If preferred mating method is not used, why **NOT**? [____]

Mating Methods	**Reasons for preferring mating methods**	**Why preferred method NOT used**
1=AI only	1=Upgrade local zebu to dairy	1= too expensive
2=Hired bull only (natural method)	2=Maintain pure breeding	2=not available
3=Natural controlled	3=Produce superior offspring	3=extension advise
4=Natural uncontrolled	4=Most available method	4=other reason
	5=Extension service advice	
	6=AI service advice	
	7=High rate of conceptions	
	8=Insufficient number of bulls	
	9=Other, specify	

2. Which breeding services are available in the area? Tick if available

Breeding services available	Tick if available NOW	Tick if available 10 years ago	Indicate when last used (month/yr)
[____]	[_________]	[_________]	[_____ _____]
[____]	[_________]	[_________]	[_____ _____]
[____]	[_________]	[_________]	[_____ _____]
[____]	[_________]	[_________]	[_____ _____]
[____]	[_________]	[_________]	[_____ _____]
[____]	[_________]	[_________]	[_____ _____]

Breeding services

1 = AI private inseminator	6 = Bull Own
2 = AI GoK	7. = Bull Neighbor
3 = AI Cooperative	8 = Bull Hired
4 = AI NGO	9 = Bull Project
5 = AI Other specify _____________	10 = Bull other specify ___________________

3. **Have you used AI in the past 5 years**? **YES [___] NO [___]**,

   If **YES**, for any AI services used in the past fill in details as required in the table

   If **NO**, go to question 9

AI service type used	Method used to contact the inseminator	Distance to inseminator base/office (Kms)	Date of last usage	Inseminations to achieve pregnancy (average)	Who chooses semen?	How many different breeds were offered	Time (hrs) of response to farmers call	Cost per single service		
								Semen + service	Transport	Total
[___]	[___]	[___]				[___]	[___]	[___]	[___]	[___]
[___]	[___]	[___]				[___]	[___]	[___]	[___]	[___]
[___]	[___]	[___]				[___]	[___]	[___]	[___]	[___]
[___]	[___]	[___]				[___]	[___]	[___]	[___]	[___]
[___]	[___]	[___]				[___]	[___]	[___]	[___]	[___]

Codes for AI services	**Method to contact inseminator**	**<u>Who chooses semen</u>**
1=Private Inseminator	1=Telephone	1=Farm owner/manager alone
2=GOK AI	2=Messenger/farmer	2=Other HH member
3=Cooperative AI	3=Cow is taken to inseminator	3=farmer with advice from inseminator
4=NGO AI	4=Other specify	4=Inseminator alone
5=Other AI specify_______________		5= Other specify____________________

4. What are the three MAIN the problems faced when using AI service providers? [___] [___] [___] **No Problem** [___]

Problems with service (codes for 4)	**AI service provider for Q5**
1=Too expensive	1=Private Inseminator
2=Long distance to inseminator	2=GOK AI
3=Too many repeats	3=Cooperative AI
4=Low quality semen offered	4=NGO AI
5=No variety of breeds on offer	5=Other AI specify_______________
6=Other specify____________	

5. Have you ever been offered imported (AI) semen? [___] YES [___] NO

   If YES, which service provider (s) offered the imported semen? [___] (**Use codes in 4**)

6. Do you prefer: imported semen [___]/Local semen [___]

   Reasons [____] [____] [____]

Reasons for preference
1=Higher quality
2=Cheaper
3=More effective (fewer repeats)
4=Wider variety
5=Other specify ______

7. Do you keep the **AI handset /Records/Straws** [___]=YES[___]=NO

   If kept, who keeps [____] and why? [____]

Who keeps	**Why**
1=Husband	1=For breeding purposes
2=Wife	2=To know when cow is due
3=Farm manager	3=Other reason specify____________
4=Inseminator	
5=Other specify____________	

9. Have you used BULL SERVICES in the past 5 years? **YES [___] NO [___]**

If **YES**, for any BULL services used in the past fill in details as required in the table

If **NO**, go to question 11

Of bull service type used	Distance to the bull's location (Kms)	Date of last bull usage (mth /yr)	No. Of Services to achieve pregnancy (average)	How many different Bulls were available	Who chooses the bull	Cost per single service	Any Known incidence of Venereal Disease?	How long is the BULL left with the cow (hrs)?
[___]	[___]		[___]		[___]			[___]
[___]	[___]		[___]		[___]			[___]
[___]	[___]		[___]		[___]			[___]
[___]	[___]		[___]		[___]			[___]
[___]	[___]		[___]		[___]			[___]

Codes for bull services	Who chooses bull
1= Bull- own	1=Farm owner/manager alone
2= Bull- neighbor	2= Other HH member
3= Bull Hired	3= Bull owner
4= Bull- project	4= Extensionist
5= Bull other, specify __________	5=Other specify

10. Which type of **bull** do you prefer [___] Zebu Bull [___] Cross Bull [___] Pure bred Bull?

11. What are the **MAIN** problems faced when using **Bull Service** providers? **[___] [___] [___] No Problem [___]**

Problems with bull service
1=Venereal Diseases
2=Poor quality animals
3=Conception difficulties
4=High potential for inbreeding
5=Other specify_______________

SECTION F: ANIMAL HEALTH AND MANAGEMENT

1. Have you **dewormed** in the last 12 months? [___]=YES [___]=NO (tick)

   If **Yes**, please state **how used** and the **number of treatments in the last 12 months**

	Adults	Weaners	Suckling Calves	Whole herd
Nature of deworming? (**See Codes**)	**[___]**	**[___]**	**[___]**	**[___]**
Times in last 12 Months	**[___]**	**[___]**	**[___]**	**[___]**

Nature of deworming
1 = only on sick animals
2 = as preventive measure

2. What are the **3 worst animal health problems** affecting your herd (in order)?

	Disease 1	Disease 2	Disease 3
Which disease? (in order) (codes)	[______]	[______]	[______]
Breed of animal most commonly infected.	[______]	[______]	[______]
Animal type most affected	[______]	[______]	[______]
Age of animals most severely affected **Indicate units used**: 1 = months, 2 = year [____]	[___ ___]	[___ ___]	[___ ___]
Total number of **disease events** in last 12 months	[______]	[______]	[_______]

DISEASES	**BREED**	**ANIMAL TYPE**
1=East Coast fever	1 =Hostein-Friesian (pure)	1 = All
2=Anaplasmosis	2 =Hostein-Friesian (cross)	2 = All cows
3=Mastitis	3 =Ayrshire (pure)	3 = Lactating cows
4=Respiratory / Pneumonia	4 =Ayrshire (cross)	4 = Heifers
5=Diarrhea	5 = Jersey (pure)	5 = Oxen
6=Intestinal worms	6 = Jersey (cross)	6 = Calves
7=Trypanosomosis	7 = Guernsey (pure)	7 = Draft animals
8=Lumpy skin disease9=Anthrax	8 = Guernsey (cross)	8 = Adult bulls
10= Reproduction (abortion, fertility)	9 = Sahiwal	9 = Small ruminants
11=FMD (Foot & Mouth)	10 = Boran	10 = Others (specify) _________
12=Milk fever	11 = Local Zebu	
13 = Foot Rot	12 = Undefined	
14 =Black quarter	13= Other (specify)_________	
15= Don't know		
16 = Other (specify)___________		

3. when your animals need health treatment, are services available? [__]=YES [__]=NO (tick)

If **YES**, tick if the following veterinary service providers are readily available in the area

Vet service provider	Tick if available in the area
Government veterinary officers	[___][
Private veterinary officers/Agrovet	[___]
Use of traditional herbs/technology	[___]
Natural cure (No treatment)	[___]
Community-Based Animal Health Workers (CBAHWS)	[___]
Treatment by Owner	[___]
Neighbors and other villagers	[___]
Others specify ____	[___]

5. Vaccination

a. Have your **cattle been vaccinated** in the last 12 months? [___]=YES [___]=NO (tick)

NB: Only record for **private vaccinations** (NOT MANDATORY GOVT vaccinations)

b. If **YES** against which disease(s)? (**use codes**)

	First	Second	Third	Fourth
Zebu	[___]	[___]	[___]	[___]
Grade	[___]	[___]	[___]	[___]

Vaccinations	7 = Lumpy skin disease (LSD)
1= Foot and Mouth Disease (FMD)	8 = Brucellosis
2= Rinderpest	9 = Rift Valley Fever
3= C.B.Pleuropneumonia (CBPP)	10 = ECF infection & treatment
4= Anthrax	11 = Don't know
5= Black quarter	12 = Other (specify)____________
6= Haemorrhagic septicaemia	

6. Ticks:

a. Do ticks affect animals in the area? [___]=YES [___]=NO (tick)

b. If **YES**, what **tick control** practices do you use? [___][___][___] (codes)

1= None	4= Hand picking
2= Acaricide	5= Traditional treatments
3= Grazing restriction	6 = Other specify _____________

7. How many times has an Extension agent visited in the last 12 months [____]

SECTION G. RECORDING AND MEMBERSHIP IN ORGANISATIONS INVOLVED IN DAIRY PRODUCTION

1. Do you keep **written records** for your grade dairy cattle enterprises? [___]=YES [___]=NO (tick)

If **yes**, which one(s) (list) [___] [___] [___] [___]

Written Records
1= Breeding records
2 = Production records
3 = Veterinary (treatment) records
4 = Sales and purchases

If **No**, Why NOT? [___]

Reasons for not keeping records
1= don't know how to
2 = No reason to keep records
3 = Type of animals kept
4 = other reason (specify)____________

2. What **kind of animal identification system** for cattle do you use in your farm? (List)[___] [___] [___] [___]

Animal identification system	
1 = None	4 = Branding/notching/tattooing
2 = Name	5 = Colour
3 = Tag number	6 = other (specify) __________

3. membership to organizations:

a. Do you belong to any farmer group(s)? [___]=YES [___]=NO

b. If **YES** which one(s) [___][___][___]

Farmer group	
1=Farmer Cooperatives	NGO
2=Self Help groups	Commodity Groups
3=Community Based Organizations	Others specify ______________________

c. If **NO**, Why not? [___] [___] [___] (See Codes below)

d. Do you belong to a breeding society? [__] YES [__] NO

e. If **NO**, Why not? [___][___] [___] (See Codes below)

member of a farmer group or breeding society	
not available in the area	no purebred cattle kept
too expensive	society is elitist
don't see any benefit	Other, specify ________________
few animals	

SECTION H: CROP-LIVESTOCK INTERACTIONS (INPUT-OUTPUT RELATIONS)

1. Grade Dairy Cattle Inputs: How much did you buy in the last 12 months and what was the unit price? (If quantity or unit uncertain, record total expenditure)

Types of Inputs	**Market Intlet**	**Quantity (no. of units)**	**Unit Price**	**Total Cost**
(a) Animal feeds				
I. Dairy meal				
ii. Hay/straw				
iii. Silage				
iv. Mineral licks				
v. Napier grass				
vi. poultry waste				
vii. molasses				
viii. forage legumes				
ix. maize stover (green/dry)				
(b)Vet services				
i. Acaricide/dipping				
ii. Antibiotics				
iii. Vaccines				
iv. Dewormer				
© Breeding stock				
i. Calves				
ii. Heifers				
ii. Mature cows				
iii. Bulls				

2. Grade dairy cattle outputs (also outputs from other farm livestock): How much did you sell and if quantity uncertain, record total income.

Types of outputs	**Market Outlet**	**Quantity (no. of units)**	**Unit Price**	**Total Cost**
Grade dairy cattle products				
I. Milk				
ii. Heifers				
iii. Bull Calves				
iv. Female calves				
v. Young bulls				
vi. Culls				
vii. Manure				
Other Livestock products				
i. Eggs				
ii. Manure				
iii. Local chicken				
iv. Broilers/Layers				
v. Dairy goats milk				
vi. Goats				
vii. Sheep				

3. Crops inputs: How much did you buy in the last 12 months and what was the unit price? (If quantity or unit uncertain, record total expenditure)

Types of crops Inputs (include cash and food crops)	**Market Inlet**	**Quantity (no. of units)**	**Unit Price**	**Total Cost**
Seed: Maize				
Beans				
Fertilizer: DAP/SSP				
CAN/UREA				
Manure				
Land preparation				
Cash crops				
Tea				
Coffee				
Sugar cane				

4. Crops outputs: How much did you sell in the last 12 months and what was the unit price? (If quantity or unit uncertain, record total income)

Types of crops outputs (include cash and food crops)	Market Outlet	Quantity (no. of units)	Unit Price	Total Cost
Cash crops marketed				
Tea				
Coffee				
Sugar cane				
Horticultural crops				
Food crops marketed				
Maize				
Beans				
Groundnuts				
Sim sim				
Vegetables				
Crop by products				