FOREST FENCE IMPACT ON ACCESS TO FODDER AND DEVELOPMENT OF DAIRY PRODUCTION: CASE OF EBURU FOREST, 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:

I dedicate this work to my parents Joseph Peter Owino and Agnes Anyango Owino. And to my daughters Sheela and Hawi Odera. Thanks dad for ensuring I got an education and for always reminding me that I was capable of doing all I wanted to, and mum for all the prayers you made for us, for always being there during the hard times and for the good laughter.

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ABBREVIATIONS

FAC	Forest adjacent communities
MFTF	Mau Forest Task Force
GDP	Gross domestic product
KEFRI	Kenya Forestry Research institute
NTFP	Non-timber forest product
CFA	Community forest association
FAO	Food and agricultural organization
DFID	Department for international development
KNBS	Kenya national bureau of statistics
PRA	Participatory rural appraisal
KALRO	Kenya Agriculture and Livestock Research organization
ADC	Agricultural development cooperation
TLU	Tropical livestock units
FMD	Foot and mouth disease
ECF	East coast fever
MOLD	Ministry of livestock development

FOREST FENCE IMPACT ON ACCESS TO FODDER AND DEVELOPMENT OF DAIRY PRODUCTION: CASE OF EBURU FOREST, KENYA.

GENERAL ABSTRACT

Eburu forest is an important catchment area within the Eastern most part of the greater Mau forest. Its continued destruction and degradation prompted the government, Rhino ark and other stakeholders to erect an electric fence which restricted access to the forest and forest resources. Dairy farming, an important economic activity amongst the forest adjacent communities relied heavily on forest for fodder and grazing fields of which previously they had unlimited access due to its porous borders. This study documented the changes before and after the fencing.

A random stratified survey was carried out on 105 small holder dairy households in Kiambogo village within 1-5 kilometers radius from the electric fence. Amongst the respondents interviewed 98 % kept livestock and out of whom 90.5% were located between1-3Km from the forest gate. Farmers kept both exotic and indigenous breeds. Eighty four percent of the cattle were exotic or their crosses (Friesian, Ayrshire, and Jersey) while 16% were indigenous breeds (Boran, Sahiwal and Zebu). Dairying was ranked as the second most important source of income after crop production further emphasizing its importance.

The cow's average age at first service was 23 months; average age at first calving was 30.2 months while average milk production was 3.9 Kg per cow per day and 45% of the recorded diseases were within one kilometer radius of the forest. Foot and mouth disease accounted for 15.6 % of the diseases recorded East coast fever 14.4%, pneumonia 7.8% while eye infections and Anaplasmosis accounted for 3.3% and 45% respectively of the diseases recorded.

The study established that 45.2% of farmers grazed their animals before fencing compared to 16 percent after fencing while there was an increase in the number of farmers using stall feeding from 30 percent to 50% with an increase of 4.8% and 10.5% in daily fodder intake and price of fodder respectively. On land use, there was a 4% increase on the total land acreage used for dairy from 18% before fencing to 22% after fencing whereas 97.5% of farmers had established their own farm fodder after the fence.

Though the study was conducted one year after the fence, the result shows that it led to changes in production system from extensive grazing to intensive and semi-intensive system, an increase in adoption of improved dairy breeds and better dairy husbandry. Positive aspects of Eburu forest fence were observed through forest regrowth, predictable rainy season, and recharged and flowing springs heads.

Key words: Eburu forest, electric fence, fodder availability, dairy production, land use changes.

CHAPTER 1: EBURU – INTRODUCTION

1.1 BACKGROUND

Currently forests occupy 4 billion hectares or 30% of the world land mass and offer a variety of services to the human population and the environment. Kenya has 56.9 million hectares of land of which 4.47 million hectares are covered with forests, equivalent to 7.8% of the country, according to (FAO, 2010; MENR, 2016).

The Mau Forest Complex is the largest closed-canopy forest ecosystem in Kenya comprising 21 forest blocks and a critical water tower in the country. It covers approximately 400,000ha located at 0°30' South, 35°20' East within Gilgil Sub-county Nakuru County. It is a major source of major rivers and streams that make up the hydrological systems of Lakes Baringo, Bogoria, Nakuru, Naivasha, Natron and Victoria (Kipkoech *et a.,* 2011)

Mau Eburu forest block is the easternmost of the 22 gazette forest blocks that comprise the vast Mau Forest Complex. Mau forest supports more than 8 million people and their livestock (Langat and Cheboiwo, 2010) but due to its continued destruction by human activity and the complexity of numerous factors as widely documented by (Menr, 1994; Wass, 1995; Matiru, 1999) their lives and livestock are exposed to the risk of drought, hunger and loss of livelihood and therefore its existence cannot be over emphasized.

Eburu literally means 'Smoking Mountain' in the Maasai community probably due to its volcanic nature. Eburu forest is source to river Ndabibi that flows into Lake Naivasha that supports the multi-billion flower industry in Naivasha. The forest is also home to the remaining few critically endangered Eastern Mountain Bongo (*Tragelaphus eurycerus Isaaci*). Charcoal burning had become synonymous with Eburu forest with charcoal kilns dotting all corners of the forest. Charcoal burning and indiscriminate clearing of the forest for illegal settlement had

become norm. However, by the time the fence was put up, conservation measures had significantly reduced charcoal burning. There was need for sensitization on the need for conserving the forest and steady reduction in forest dependence.

These and many years of destruction sprung the Government of Kenya, Rhino ark and other stakeholders into conservation prompting the construction of an electric Eburu fence as part of a conservation initiative. The Fence was aligned along the 50km gazette forest boundary to enclose the entire on the 87km^2 forest (Rhino ark, 2013). The success of the fence was after a great attitude shift on the conservation approach amongst the forest adjacent communities (FAC), the forest and wildlife department and huge resource mobilization from stakeholders. It was noted that once the FAC essential needs of water provision, livestock grazing protocol, human-wildlife, pouching control and natural forest control needs were met, and they appreciated the efforts to conserve the forest (Church, 2015).

The establishment of community forest association (CFA) ensured that FAC voices and needs were heard and addressed. Their involvement and participation from pre-planning and the actual erection of the fence instilled ownership to the project and this was vital for sustained integrity of the forest. The CFA was in-charge and set protocols for forest resource utilization, for livestock farmers were to pay 140 sh per cow and 40 sh per sheep per month as access fee. Goats and domestic dogs were totally excluded and the number of livestock at any particular time was to be regulated. Livestock also were fully excluded from the reforested areas. There was 50 % compliance in paying the access fee and coming from a period of unrestricted access this was considered a milestone which was expected to reach 100% once the full benefits of the forest were realized and the public fully understood the policy (Kirui, personal communication CFA chairman 2014). Livestock were not allowed to drink in the springhead within the forest to

reduce pressure on the springheads. An estimated 400 cows and 200 sheep accessed the forest for grazing daily noted the CFA chairman.

Dairy farming was one of the main economic activities beside crop agriculture. Due to limited access to fodder and grazing area farmers have had to adjust their production systems and land use by adopting more intensive system and establishing fodder on their own farms. The study evaluated the impact of fencing on fodder availability and livestock production system amongst FAC.

1.2 Problem statement

Due to population growth and urbanization, pressure on land had greatly led to encroachment of forest land for agriculture and settlement (Walubengo and Kinyanjui, 2010). In the developing world, up to 20% of the households derive their livelihoods from the forest (Angelsen *et al*., 2014) especially in terms of fuel and fodder as reported by (Vedeld *et al*., 2004). The continuous destruction prompted the government and other stakeholders to initiate conservation measure. A ring forest fence was erected around legal boundaries of the Eburu forest. The forest fence was more pro-conservation than the livelihood of the forest adjacent communities.

Dairy farming is a major source of income to the forest fringe communities and heavily depend on how easy they can access forest fodder and water from the forest, prior to the erection of the fence dairy farmers had unrestricted access to the forest due to lack of proper demarcation of forest boundaries and weak guarding by government entities. This changed after the forest fence leading to reduced fodder availability. Dairy farmers had to make adjustments in their dairy production and land use systems to reflect on the current realities. For the success of the forest fencing, a delicate balance was required to fulfill both short term needs of fodder for local communities and long term conservation goals.

1.3 Justification

Dairy farmers appreciated the advantages and benefits of a healthy forest but at the same time acknowledged that they depended a lot on the forest for fodder, grazing and water for their livestock. A delicate balance was therefore required to safe guard the long term goal of conserving the forest with the short term expectations of the farmers. This noted, without the support and ownership of the FAC to the well-intended conservation efforts, the results could be catastrophic and fail to achieve both agendas of forest conservation and local communities' livelihood security. The fringe communities presume the forest and its resources as their birth right and as such they feel entitled to unlimited access as they have done before.

In Kenya, certain laws have been passed to allow for common management of forest resources as captured in the (Government of Kenya, 2016). This law emphasizes the need to involve the local adjacent communities and other stakeholders in management, conservation, access rights and benefit sharing models in-order to protect the forest in a more sustainable way for future generations. To attain this, FAC should be empowered to reduce their consumption of forest products to sustainable levels or given alternatives or incentives to venture into other non-forest enterprises with an aim of reducing pressure on the forest.

Intensive and or semi-intensive dairy farming is an emerging enterprise that farmers have adopted prominently around Eburu forest as it offers a more ecological and economic friendly venture compared to the extensive indigenous livestock they kept earlier. Farmers extract fodder from the forest for their livestock via grazing or cut and carry. This production system offers the FAC alternative income. With an improved or better income and alternative source of livelihood, farmers will reduce their dependency on the forest.

Erecting the fence led to a dynamic shift in which access rights are moderated, amount of fodder harvested was controlled, land use changes arose, breeds of cows kept changed, milk yields and farm yields improved and adjacent communities realized an increase in personal income. The dilemma was how to balance conservation and livelihood security. As reported earlier (DfID, U. K. (1999). most conservation efforts have concentrated on preserving forest with little emphasis on social and human contribution of the forest.

Although recently, there has been a purposed effort to try and link livelihoods to forest conservation, there hasn't been a systematic approach on the same in regards to intensive dairy farming amongst fringe communities in Eburu forest. The study explored and documented the impacts brought about by Eburu forest fencing.

1.4 Objectives

The overall objective of this study was to determine the effect of fencing Eburu forest on fodder and grazing areas availability and its consequences to dairy cow production and land use systems within communities living adjacent to the forest.

1.4.1. Specific objectives

I. To trace the time changes in dairy cattle production systems and land use among the communities living adjacent to the Eburu zone of the Mau forest.

II. To identify the types, sources and quantities of fodder utilized by forest adjacent communities before and after fencing.

1.5 Hypothesis

1. Dairy production systems in areas adjacent to Eburu forest have remained the same after fencing.

2. Fencing Eburu forest has not affected fodder availability.

CHAPTER TWO

LITERATURE REVIEW

2.1 Eburu Forest cover in Kenya

Mau forest is one of Kenya's water tower and the largest with a very large catchment area. It soaks rain water and helps recharge underground water. It's a source of 12 rivers that are vital for agriculture and Hydroelectricity generation downstream. The rivers supply over 4 million people with water and as reported by (Langat and Cheboiwo, 2010). The economic benefit can be placed at $1.3 billion per year which is equivalent to 2% of Kenya Gross Domestic Product. Hence its importance cannot be further emphasized, but due to various exposures, according to Mau Forest Task Force (MFTF) (2009), between 1996 and 2005 thousands of the original 400,000 hectares have been expropriated. Forest settlement, mismanagement of industrial forest, indiscriminate extraction of the forest, with fires and forest grazing were identified as the major causes of degradation. Forest loss led to environmental degradation and drought (Wafulla Nabutola, 2010). Eburu forest is the eastern most part of the Mau forest. It impacts positively to various economic activities in the horticultural, flower and tourism industry. It's the source of Ndabibi River and forms the catchment area for Lake Elementaita and Naivasha.

Langat and Cheboiwo, (2010) reported that the forest provide on average 11 bales of hay per household and 14.6m^3 of water for livestock. Mau forest offers livestock support totaling to remarkably very little information on household incomes derived from Mau forest; estimated at times to be up to 20% of total income as noted by (Cavendish, W. (2000);Angelsen, A., and Wunder, S. (2003); Vedeld *et al.,* 2004). This information is important to policy makers when formulating legislations to balance the need for forest conservation and sustainable forest dependent livelihoods. The new institutional shift (FAO, 2000) in forest management where there is

decentralization of forest management to community based levels, (Agrawal and Gibson, 1999) offers a mechanism for efficient sustainable forest management through incorporating and interlinking various aspects of economic, environmental, social balance and local knowledge in decision making and benefit sharing. A sense of ownership is in-cultivated to the local communities and hence a plus to the conservation efforts.

2.2 Forest fencing and access

Forests offer consumptive resources, spiritual and aesthetic needs, employment, and ecological services such as carbon sequestration and water provision (Shackleton *et al.*, 2007). But, in many forest communities tend to be located in remote areas with less exposure to markets and technological progress, urban centers and other infrastructural projects. Despite these challenges, in many instances, legislation sets heavy access demands to small forest users and thus discriminates against them in favor of larger organizations with greater influence (Larson and Ribot, 2007). These influential organizations are market oriented and thus cause major forest destruction through over exploitation of forest products.

As noted by conservation policies should be inclusive and affordable to local communities and reward when they contribute to forest conservation (Larson and Ribot, 2007). Available empirical evidence suggests that most policies impose high cost on local people without necessarily compensating them for participating in forest conservation causing antagonism with local people who might have otherwise cooperated with forest conservation efforts. Hence the conclusion is that (World Bank, 2004) most legislation are not pro-poor whom opinion doesn't inform legal process hence many of the barring legislation such as fees paid to access forest resources, forest guards manning entry in and out of forest, fencing of the forest, penalties in form of fines, forest buffer zones, high cost for joining forest user groups and pre-conditions set for joining forest user groups.

Once the FAC lose their traditional sense of ownership, responsibility, control and benefits of the forest, they become negative to government management and control. In this regard therefore it is important to offer communities incentives and legitimate involvement in forest management (Barrow, 1990; Emerton, 1999; Emerton and Mogaka, 1996).

Collaborative action between the local community and the state which set the laws and has the legal right to manage state forests but normally without the ability to do the same due to financial and human capacity restrains (Ostrom, 1992). The informal local rules that have evolved over many generations can result to conflicts and depletion of the forest resources when they fail. Dependency on forest resources and involvement in its conservation is greatly influenced by household distance to the forest as reported by (Sapkota, I. P., and Odén, P. C. (2008)). Households more adjacent to the forest have more access to forest resources regardless of allocation rules hence they accrue more benefits compared to those far away from the forest (Varughese and Ostrom, 2001)

2.3 Forest grazing and cut and carry fodder

An estimated 10% of Kenya population, which is 530,000 forest adjacent households or 2.9 million people live within five Kilometer radius of forests and they derive almost 70% of their cash income from the forest (Wass, 1995)

Over exploitation of Mau forest has resulted in critically low biomass availability and adverse effects on livestock production and productivity. Overgrazing makes the available forage to have a poor nutritional profile and low available energy, proteins and minerals further compounding the issue of under-nutrition on the dairy cows (Misri, 1988).

Competition for arable land between food crops and fodder due to population increase creates an enormous challenge to dairy farmers and unless milk productivity becomes remunerative

compared to other crops there will be very little chance of own farm fodder production. To compensate for this low productivity, farmers are forced to keep large herds of cattle for grazing leading to further degradation (Fernández-Rivera *et al.*, 2005).

Forests takes a long time to mature and start to generate revenue so paying for forest grazing rights offers a string of revenue. Dairy cattle aid with weed control and reduce fire risks by foraging on the undergrowth. Grazing also convert some nitrogen locked up in ground vegetation into mineral nitrogen in animal urine thus improving nitrogen cycle within the ecosystem (Adams, 1975).

Nutritional constraints to grazing ruminants stem primarily from feed scarcity and seasonal fluctuations in feed supply associated with rainfall patterns. Grazing herds are managed differently with some management practices decreasing grazing time, feed intake and increased energy expenditure for walking. Land tenures and user rights changes occasioned by demographical shift also constrains animal nutrition by limiting herd mobility and access to feed resources.

2.4 Dairy production in Kenya

Consumption of dairy products has increased tremendously in Kenya due to various factors one being population increase and lifestyle changes, urbanization and improvement in households incomes. Annual per capita consumption is estimated at 19 Kg for rural areas and 125 Kg in urban centers (Muriuki, 2011). Dairy production has gone through many phases in Kenya from pre-independence to present. Pre-independence phase was characterized by large scale production and export oriented, then after independence there was growth of the small holder producers followed by a period of political interference and disruption in the dairy sector, which recovered around 2003 when there was new impetus with favorable government interventions

and increase in demand (Muriuki, 2011). Bulk of milk is produced by small holder farmers accounting for up to 70% or 3 billion liters mainly from exotic breeds and their crosses.

The livestock sector contributes about 40% gross domestic products and employs 1.3 billion people and creates livelihood for one billion of the world's poor (Seinfeld *et al*., 2006) and is therefore socially and politically very significant. It also contributes 20 % of household cash without factoring home consumption of livestock products *(*Tuliahan and Nepean, 1999).

In Kenya, the livestock sector contributes about 12% of Gross Domestic Product (GDP) and 40% to the agricultural GDP. Dairy industry contributes 3.5% to the total GDP of Kenya and employs 50% of the agricultural labor force. The Kenyan dairy sector, with an estimated dairy cattle population of about 4.3 million (extrapolated from results of the 2009 census), is one of the largest and most modern in Sub-Saharan Africa. It is the single largest agricultural sub-sector in Kenya. It has grown at an average growth rate of about 4% per year in the recent past (Ministry of Livestock Development (MOLD), 2010).

Tegemeo institute estimated that 1.2 million farmers are small holder dairy farmers averaging 3-5liters per day. Hence the dairy value chain can be enhanced appropriately to address poverty and food security for the most vulnerable. This is however threatened by shortages, poor quality and high cost of feeds. These factors lead to underfeeding thus low productivity below the cow's milk production potential (Wambugu *et al.*, 2011)

The dairy industry has been growing in the current decade, after years of decline and disruption, largely highlighted by the notable collapse of Kenya Cooperative Creameries in 1997. The recent growth in the dairy production has been driven by an increase in the yield per cow (Kenya, T, 2008).

2.5 Feeds /fodder resources

In Kenya, shortage of feed is one of the major limiting factors for better productivity of livestock sector (Methu *et al.,* 2001). Feed constitutes 60-70% of the total dairy production costs. Most farmers' lack the knowledge of controlling production costs per liter and cash flows are managed informally as immediate needs arises and therefore most farmers with limited cash flows will result to open grazing (Kenya, T, 2008). However there was little information on types of fodder harvested from the forest.

Feed resources available in the country can be categorized as green roughages, dry roughages, concentrates and supplements (Qureshi *et al.,* 2002). Green roughages include fodder crops, pastures and grasses including shrubs, silages and tree leaves. Concentrates are high in energy and/or protein, low in fiber, and highly digestible. They are the expensive part of the animal feed and are used mostly in small quantities as supplements. They include cereal grains such as maize, wheat, oats, sorghum, barley, oilseed cakes and meals mainly (sunflower, cotton and soya) cereal industrial by products such as brans, polishes and molasses. Forage contributes to about 75 % of the nutrients. Dry roughages include hay, straws, stover and hulls. Green fodder is not readily available during the dry months of the year while concentrates are expensive to most farmers and not very available. Dry roughages are mostly nutrient deficient and do not meet the animal requirements making them valuable for feeding livestock only during dry season when there is fodder scarcity . Therefore the problem of under nutrition is very common in many small holder livestock farmers, dairy included.

Under nutrition is one of the main factors limiting animal production in the traditional smallholder dairy producers. The most important sources of feed for smallholder ruminant animals are the natural pastures and the fibrous crop residues (Simbaya, 2002). Due to

seasonality these materials are often of low nutritive value in the dry season and do not have the capacity to meet the nutritional requirements of livestock at this time of the year and the reverse during the wet season. To improve dairy productivity capacity of smallholder farmers, there is a need to embark on strengthening fodder conservation techniques for a year-round availability of feed resources and better improved quality of feedstuffs available to the farmer. A number of strategies have been developed and tried for adoption by smallholder farmers. These strategies are increased processing of crop-residues physically or chemically to improve nutritional value and lower the high fiber content, cut and carry stall feeding of natural pasture, planting of legume species, and reducing stocking rates in their communal grazing areas.

The quality of both concentrate/commercial and fodder feeds has remained an issue of concern to the livestock sector. Variation in milk quantity and quality is often attributed to variation in quality of feed Muriuki *et al.,* (2003). This variation is relatively high in smallholder farms since their management is more sensitive to price variations. For these farmers especially, access to information on best feed production and management practices is at best inadequate if not lacking.

FAO estimates the average yield per cow at 564 Kg per year (FAOSTAT, 2006) and 1000Kg/year with 70-80% of production coming from 600,000 small holder farmers (Omore *et al*., 1999) and 5,000 large producers (Kenya, T, 2008). These figures indicate very low productivity which could be attributed to a myriad of factors but feeds have been identified as the major factor.

Livestock feedstuff is differentiated into roughage (high in crude fibrous material), such as grass from pastures and crop residues, and feed concentrate, such as grains or oilseeds. In rural Kenya, the main feed resources include native grasslands, cultivated fodders and trees from private and

public forest, crop residues, agro-industrial by-products, and non-conventional feed resources. However, forests are major source of the feed and fodder for livestock of forest dependent communities.

2.6 Forest contributions to livelihoods

Forest contributed about 1% to the country gross domestic product (GDP) equivalent to Kenya shillings 16.4 billion and 10% of households 5km from the forest depended on forest resources for subsistence (FAO, 2010). More than 1.6 billion people depend to varying degrees on forests to supplement their livelihoods (World Bank, 2004) whereas another 350 million heavily depend on the forest **(**Timko *et al.*, 2010). In Africa, about 400 million indigenous people are almost wholly dependent on forests for subsistence or source of income from sale of fodder or other NTFPs (Arnold and perez, 2001; Kaimowitz, 2003; Sunderlin *et al.*, 2005). Forests in Africa are mostly in remote area without organized market and therefore it provides a major portion of household livelihood hence provide a great opportunity in forest conservation and livelihood security.

Many Forest adjacent communities are rural dwellers with very limited resources and in remote places. They live a subsistence life with very little market interference. Forest therefore offers them a source of income and other forest resources such as agricultural land, non-timber forest products (NTFPs), timber and other ecological benefits. Therefore overuse and degradation of the forests harms them more than other groups in the society. As rural poverty continues to increase the fate of the forest will depend on how sustainably it is utilized by involving all the potential stakeholders (Byron and Arnold, 1999; Campbell and Luckert, 2002).

A livelihood involves income-generating activities determined by natural, social, human, financial and physical assets and access to the same (Ellis, 2000). Forest assets such as trees, shrubs, herbs, game and fodder are harvested by forest adjacent households in virtually all forest

types and these supports their livelihood*(*Scoones *et al.*, 1992; Neumann and Hirsch, 2000; Cunningham, 2001).

2.7: Information gap

We Eburu forest have undergone a long period of destruction characterized by illegal logging, charcoal burning, human settlement and extensive environmental degradation. Many forest adjacent communities depends on the forest for fodder, grazing areas, water, wood fuel, bee keeping and other forest resources. Due to these factors, further destructions would have been catastrophic and therefore measures were initiated by the local community, the then provincial administration and other Non-governmental organizations. The fence was erected in the year 2013, this was a mainly conservation effort with little consideration on other inter-related aspects and forest dependency. Dairy farming along Kiambogo area depended a lot on forest fodder and grazing, however after the electric fence, access to the forest changed and this affected fodder availability.

Very little information is available on how these changes affected dairy farming and land use amongst Eburu forest adjacent communities. This study evaluated and documented these changes.

CHAPTER THREE

EFFECTS OF FOREST FENCING ON FODDER AVAILABILITY TO EBURU FOREST ADJACENT COMMUNITIES

ABSTRACT

After many years of degradation and destruction of Mau Eburu forest conservation efforts were initiated. It is the home to perhaps 12 of the fewer than 100 surviving wild population of critically endangered Eastern Mountain Bongo antelope worldwide (Rhino ark, 2012). Fodder is one of the main NTFPs especially for the livestock farmers. For Eburu forest conservation, an electrified 50 Kilometer fence was erected along the legal boundaries. The electric fence led to reduction in fodder availability to adjacent dairy farmers. The study explored the availability of livestock feeds with emphasis on fodder types, quantities, availability and feeding strategies. A pretested questionnaire was used to collect primary data from 105 randomly selected households engaged in dairy farming amongst forest adjacent communities (FAC). The study found that, after the electric fence was erected most farmers depend on their own farms for fodder, daily fodder intake per cow increased by 4.8 % as the price went up by 10.5 %. Majority of farmers depended on fodder (97.5%) and pasture (75%) respectively from own farms, daily fodder intake per cow went up by 9.2% and the average price by 10.5% after the fence. During abundance, 31.7% and 19.2% of respondent conserved fodder as hay and silage respectively whereas 76% and 12.5% bought or sold their livestock during drought. After fencing there was adoption of better dairy husbandry through stall feeding, breed selection, proper housing, better feeding and supplementation, adoption of fodder conservation techniques and disease control. Fodder selling business was also on the rise in order to cope with the arising fodder demand.

Key words: electric fence, fodder availability, livestock feeding strategies.

3.1 Introduction

Forests are defined as ecosystems with a minimum of 10% crown cover of trees and/or bamboos, generally associated with wild flora, fauna and natural soil conditions, and not subject to agricultural practices (Chokkalingam and De Jong, 2001). According to World Bank sources, there are about 1.6 billion people who derive their livelihoods from the forest either directly or indirectly (World Bank, 2004). Two hundred and forty million people live in forested areas, constituting 18.5% of the 1.3 billion people living on environmentally fragile lands (World Bank, 2004).

The disappearance of natural forests in developing countries is a problem, among other reasons, because it negatively affects the livelihoods of people dependent on forest products and services (Poore, 1986; Brosius, 1997; Maruyama and Morioka, 1998). Deforestation continues to degrade the forest significantly despite heightened sensitization on forest conservation for sustainable utilization. Mismanagement by irresponsible and corrupt behavior of politicians and government officials has been recorded as the single most chief contributor. The destruction is demonstrated by continued loss of indigenous forest, human activities and settlements, cultivation, charcoal production and grazing (Chepngeno, 2014).

Livestock production forms an important livelihood to forest adjacent communities (FAC), and as in many developing countries small holder dairy farmers face challenges in feeds and feeding their dairy cows due to scarcity of fodder, poor feeding methods, lack of extension training on available feed conservation methods hence low and or poor productivity of their livestock. Dairy farming is one of the main economic activities around Kiambogo village. Others include, wholesale and retail business, tourism and farming crops like vegetables, maize, potatoes, beans and pyrethrum.

Feeds and feeding constitute 60-70% of the total production costs in Africa and other developing countries. In Kenya, feed shortage is a major limiting factor for better livestock productivity (Methu *et al.*, 2001). Livestock production is increasingly being constrained by feed scarcity and high costs of feeds due to global inflation (Ayantunde, Fernández-Rivera and McCrabb, 2005). In most instances supply of adequate feed resources to small holder farmers in developing world depends on common grazing lands (Sandford and Ashley, 2008).

Previously the FAC had limited access to market and other infrastructure and production was mainly subsistence, however, with growth in population, increase in income and urbanization the demand for food of animal origin have increased (Delgado, Rosegrant, Seinfeld, Ehui and Courbois, 2001). This has led to the need for improved productivity and commercial production hence straining on available feed resources leading to over exploitation of forest.

Eburu fence had some positive aspects noted by the farmers such as increased springs refill and flow, two distinct rainy seasons that was previously lost, decreased incidences of human-wildlife conflicts thus better crop yields hence better cash flows which eventually enabled them to purchase dairy animals or better breeds or easily adopt better dairy husbandry. Improved security and reduced cattle rustling as rustling routes through the forests were blocked. There were regrowth of understudy vegetation in areas previously overgrazed forest patches. This paper presents the results of a survey conducted to assess effect of fence erection on fodder availability amongst Eburu forest adjacent communities.

3.2 Materials and methods

3.2.1 Study area, Location and size

The study area was part of Eburu forest located in Naivasha District, Gilgil division, Kiambogo location, Kahuho and Dunyu Buru sub location. Kahuho has a population of 1060 and Dunyu Buru 920 people (Figure 1) District statistic KNBS, 2010). Eburu forest is one of the 22 Eastern Mau blocks that cover 420,000 hectares. The forest lies between longitudes 36° 05' and 36° 16' East and latitudes 0º 40'and 0º 41'South. The study area is adjacent to the forest fence which occupies an area of 8,715.3 hectares of prime indigenous forest. The fence has various access points which serve as gates to the forest. The gates are placed within specific distances of 6Km apart from Kahuho gate to Morop power house.

3.3 Research tools

The study was carried out in the month of March and April 2015. Data was collected from organizations and people living adjacent to the forest but are involved directly or indirectly in forest and fence management and also utilized forest resources. These were local communities, government officials such as the chief, livestock extension officer, forester, Kenya wildlife service officials, Rhino ark officials, chairman of Ogiek community and the chairman of community forest association. Data was obtained from 105 households within the study area of a 5Km radius from Kiambogo and Dunyu Buru forest gate. The household survey consisted of a pretested structured questionnaire (appendix 1). The survey mainly asked about aspects of dairy farming and other economic activities. The households were randomly selected from households in Kahuho with a population of 1060 persons and Ndunyu Buru with a population of 920 persons were randomly selected by entering all the households with livestock and dairy cows in a random number generator to select the households to interview.

Study area

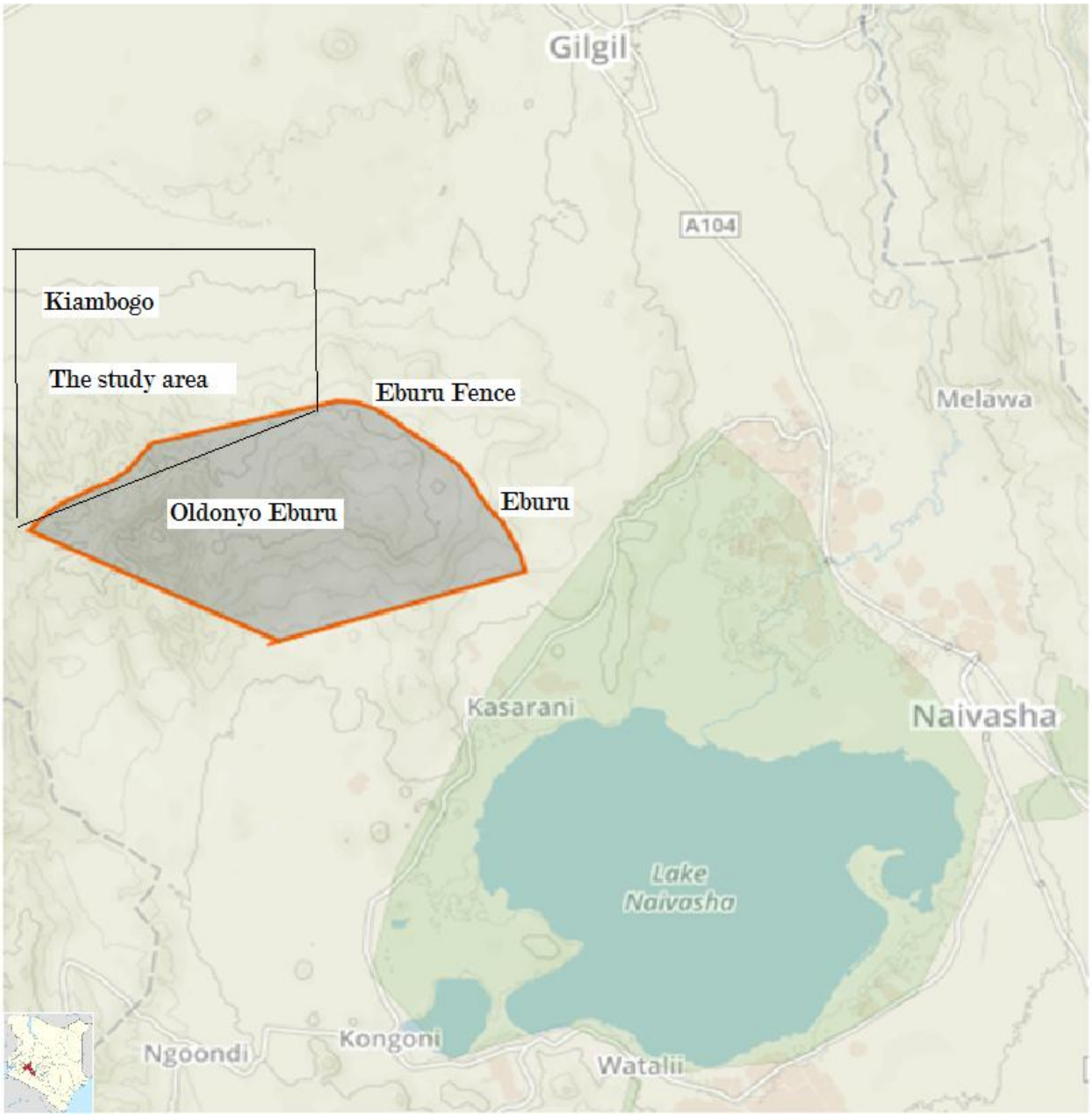


Figure 3. 1: Study area

Source: Kengen, Olkaria Geothermal

Data was collected using structured questionnaires and participatory rural appraisal tools (PRA); transect walks, activity calendars, focus group meetings, and key informants. Socio-economic data was collected using participatory rural appraisal (PRA) which, included group interviews, individual interviews, historical profiles, observations and secondary sources of information. Key informants included government officials and other stakeholders directly or indirectly involved with the forest fencing whereas candidates for in-depth semi structured interviews and focused group discussions were selected through snow ball sampling with the help of native-speaking research assistant already known informally to some members of the community. One hundred and five pretested structured questionnaires were administered. The data was recorded, summarized and scrutinized for inconsistency and then was exported to Statistical package for Social Scientists (SPSS version 16.0, 2008) and MS Excel 2010 for further interpretation. The processed data was analyzed using descriptive statistics such as total, averages and percentages.

3.4 Results and discussion

3.4.1 Daily fodder weight estimation

Daily fodder intake per dairy cow was obtained by weighing the amount of feed given to the animals per day using a calibrated hanging weighing scale as shown in table 3.1. Farmers estimate the amount of fodder using 90kg sacks (gunny bags) or 20kg buckets that were not accurate and led to underfeeding. This was attributed to the different feed densities, volumes and form of feed. The forages were offered "as it is" cut directly from the forest or farm without wilting thus high moisture content, maize stovers were offered dry. Each category of fodder was weighed using a calibrated weighing scale as used by the farmers to establish their actual weight. As farmers transition from extensive grazing to stall feeding, appropriate amounts of balanced feeds should be offered to the dairy cows. The feed offered included nappier grass mixed with

Table 3. 1: Average amount of various feed type offered to dairy cows by farmers on 'as fed' basis

Feed type	'As fed using a 90kg sack'	'As fed using a 20kg fat bucket'
	Actual weight equivalent, Kg	Actual weight equivalent kg
Grasses	22	6-8
Fodder	30	10
Cut and carry	20	8-10
Crop residue	16	6-8

* Grasses include: kikuyu grass (Pennisetum clandestinum), Rhodes grass (Chloris gayana) and couch grass (Elymus repens), Fodder: nappier grass, cut and carry include: a mixture of grass, climbers, leguminous fodder (green leaf desmodium (Desmodium intortum) and other edible plants and tubers, crop residue: maize stove

cut and carry forage from the forest; the lactating cows were supplemented with wheat bran, dairy meal and mineral salts. These feed should be offered in quality and quantities that provide the cow with enough energy, crude protein, vitamins and minerals as per the animal basic requirements and physiological state.

3.4.2 Importance of forest fodder

Nutrition and management affect production and reproductive performance such as milk production, body weight, estrous cycle, calving intervals and other fertility indices of a dairy cow (Topps and Oliver, 1993).

Before the fence, fodder from the forest was the main source of basal feed to the fringe dairy farmers. Most of their farms are small and thus depended on public land for fodder. They grazed and harvested forest resources without restriction. Dairy farmers utilized grass for pasture, poles for building dairy houses, springs and well for watering their livestock. Kenya top bee hives were used to keep bees inside the forest by the Ogiek community. Each group of the Ogiek was allocated areas to keep their bee hives. But grass and climbers such as desmodium were the most important forest feed resource for dairy farmers. Fodder from the forest was cheaper compared to fodders bought from traders and available all year through even during drought. There is also great variety of fodder in the forest both leguminous and grasses and thus provide a rich diet for the livestock.

Table : 3.2 show, the numbers of exotic dairy (Friesian, Ayrshires and Jersey) dropped by 12.7 % as the amount of fodder from the forest reduced which could be due to their heavier body weight and thus require a higher dry matter. Farmers with the exotic breed preferred stall feeding but with increased distance and cost of fodder the cost of production went up hence they preferred

Table 3. 2: Mean live weights and numbers of livestock kept before and after fencing at Kiambogo

	Numbers			Weights (Kgs)		
Livestock	Before fencing	After fencing	% difference	Before fencing	After fencing	% difference
Exotic dairy	63	55	-12.7	313.3	315.2	0.6
Dairy crosses	134	216	61.2	269.3	266.1	-1.2
Local cattle	16	308	1925.0	233.3	233.3	0.0
Sheep	590	528	-10.5	24.7	28.0	13.6
Goats	192	149	-22.4	21.6	23.0	6.6
Donkeys	41	47	14.6	143.3	145.9	1.8

** Exotic dairy: Friesian, Ayrshires and Jersey*

exotic inter-crosses or exotic crosses with, Boran, Sahiwal and local cows those are more adapted to walking long distances and hilly terrain. The number of dairy crosses increased by 61.2%; they are smaller in frame, better adapted to the local conditions and can walk for a longer distance. Friesian and Ayrshires were the main crosses at 20.6 % and 12.2% respectively. Seasonal changes in numbers of animals grazing in the forest were noted corresponding to dry or rainy season. During dry season, there was a sharp increase in the numbers of local cattle from 16-380 brought by the Maasai who migrate into Kiambogo area looking for water and pasture in the forest. This routine seasonal occurrence during dry months further shows the importance of the forest as a fodder bank. During the rainy season few animals graze in the forest as there is plenty of fodder in own farm, communal grazing lands and roadside grazing. The pastoralists were blamed for outbreaks of Foot and mouth disease in the area. The number of sheep and goats dropped due to fodder pressure. Goats were restricted from forest grazing has being browsers they cause damage to shoots and seedlings hence they hinder forest regeneration (Mr Kirui, Community Forest Association, 2014). Donkeys were used to transport fodder and other farm requirements and the increase in their number indicates that more farmers are adopting zero grazing due to their use in fodder transportation.

Body weight change is a factor of nutrition, animal health and production system. In stall feeding the animal nutrition is constantly monitored and supplementation availed as needed, the cow does not walk for long distances consequently conserve the energy required for maintenance and production. Over stocking led to under or malnutrition, environmental degradation through soil erosion, soil compaction, trampling of seedlings and breaking of tree branches hence the need for proper stocking density. The exotic cows gained whereas the dairy crosses lost weight at 0.6% and -1.2 % respectively. The small stocks gained weight with sheep gaining by 13.6% and goats

by 6.6%. This gain could be attributed to decrease in the number by -10.5% and -22.4 % respectively as shown in table 3.2. With decreased fodder availability, poultry farming uptake went up especially for improved local chicken as it offered farmers alternative source of income not directly depended on the forest and was less capital intensive. Commercial meat birds rearing was on the rise. Exotic birds are more market driven thus indicating a shift to more commercial farming. The closeness to Kenya Agriculture and Livestock Research organization (KALRO) Naivasha also contributed to the high uptake of improved local birds.

3.4.3 Fodder availability

Through controlled entry points there was limited grazing hours, grazing time and overnight grazing was no longer allowed. The number of animals allowed the type of fodder to harvest (green fodder trees prohibited) were all monitored. All these factors regulated the amount of fodder harvested and consequently decreased feed intake with farm distance and topography in relation to the fence influencing availability. A farmer adjacent to the forest who previously walked directly into the forest was now forced to take a longer route to enter the forest through the gates. The distance and the fodder transport cost isolated many farms or made it expensive for many farmers to harvest fodder or graze into the forest.

Land use changes led to a drop in acreage under food and cash crop whereas acreage used for dairy activities and own farm forestry increased. As shown in table 3.3, the net effect was that the bulk of the forage came from own farms. The shift towards own fodder production relieves off pressure from the forest as the main source enabling a sustainable coexistence. Cow manure was important for improving soil fertility and was used as an alternative to inorganic fertilizer as a result saving the farmer that expense.

Table 3. 3: proportions of Sources of fodder and water for dairy farmers

	Source fodder and water (%)		
Feed	forest	own farm/market	both forest and own farm
fodder grass	2.5	97.5	0.0
local pasture	23.7	75.3	1.1
cut and carry fodder	63.0	35.6	1.3
crop residue	0.0	100.0	0.0
Water	38.4	56.6	5.1

Napier grass (*Pennisetum purpureum*) was the main fodder grown in small plots at the edge of the farms or in contours to mark farm boundaries or as a soil conservation measure. The same was noted by (Bayer, 1990). The FAC used nappier grass as the main basal feed with 97.5 % from own farm. Unimproved pasture (Kikuyu, star and couch grass) and Rhodes grass were used as pasture, 23.7 % was from the forest while 75% was from own farm. Cut and carry fodder was from the forest 63% and 100% of crop residue was from the farm. Water fetched from the forest was 38% and 56.6 % from own farm through water harvesting, government supply or from a local borehole.

Seasonality in availability of quality forage causes a major nutritional challenge especially during the dry season primarily due to feed scarcity and poor quality feed. Nutritional stress is a major constraint to ruminant livestock production. After the rainy season, quantity and quality of grazing pasture depreciates rapidly, leaving cereal crop residues as the major feed resource. These residues are low in nitrogen and high in crude fibre, characteristics which restrict intake and digestibility which results to underfeeding.

During the wet season grazing levels in the forest went down as most farmers had fodder in their own farms, movement of the animals was also restricted to reduce damage to the crops on farms. During the dry season there was less restriction, cows grazed both on crop residues on the farm and the forest as the season progressed. Fodder prices were low during the wet season and higher during the drier season due to scarcity. The higher market prices for forage and supplements prevented many farmers from purchasing further lowering the nutritional status of the animals.

Numerous factors hindered access to forest resources, some included access fees , forest guards , forest fence, penalties in form of fines, forest buffer zones, high cost for joining forest user groups, pre-conditions set for joining forest user groups. Before fencing dairy farmers had easy

access to fodder, they travelled short distances to collect fodder in the forest, there was no control of the number of animals entering the forest, amount of fodder harvested, frequency of grazing or cut and carry fodder harvesting from the forest. Due to lack of clarity and conflicting interest on their inherent and traditional rights to graze in the forest, dairy farmers were forage constrained but still 53.8 % of farmers did not pay the access fee indicating low compliance.

3.4.4 Fodder types and feeding strategies

Mau forest supports a large number of livestock that depend on it for fodder resources. The eastern Mau block where Kiambogo falls has a total of 2,875.16 tropical livestock units (TLU) within 5 Km radius from the fence (Langat and Cheboiwo, 2010)

Forage resources in Kiambogo are shown in table 3.4. Napier grass was the most abundant basal feed and utilized by majority of farmers. Rhodes grass utilized as baled hay or loose grass was mainly used during the dry season and was mainly bought from the market. Maize stover utilized green or dried was also an important feed during the dry season. Its availability was greatly reduced by maize lethal necrosis disease that discouraged farmers hence reduction in acreage under maize. Cut and carry forage was composed of herbs, climbers, crawlers, grasses and other leguminous plants found inside the forest. Other feed resources from the market included dairy meal and agricultural process by-products such as brans and oil cakes (Table 3.5). An increase in the amount of fodder use was noted after fence erection from an average of 30.4 kg/cow to 33.2kg/cow representing a 9.2% increase and a marked increase in cost per kg was recorded in all categories of roughages and concentrates given to the cows with a major increase on fodder grass and local pasture at 62.5 and 51.6 percent respectively.

The overall cost of feed per kg also went up by 3.3sh per kg which could be attributed to scarcity of fodder as the level of intensification increased, whereas in local pasture it could be due to the

Table 3. 4: Available fodder resources at Kiambogo.

Fodder resources available	
Maize stover - dry	grown in most farms, residue after harvesting is feed to dairy cows
maize stover -green	fed to dairy cows after harvesting the maize green, or when planted as fodder
Napier grass	main basal feed found in most farms
Rhodes grass	recently introduced, few farmers have it loose or balled, bought from outside during drought
Local pasture/grass	available in common grazing areas
Cut and carry	harvested from the forest, a mixture of grasses and herbaceous plants

Table 3. 5: Average daily fodder intake and cost of feed per Kilogram.

	Before fencing		After fencing			
	Kg/cow	Price/Kg	Kg/cow	Price/Kg	% change amounts	% change price
Local pasture	10.54	7.01	11.17	9.42	6.05	34.39
Fodder	6.89	4.21	7.59	6.53	10.04	55.15
Cut and carry	4.36	3.64	4.71	4.77	7.89	30.98
Crop residue	3.95	3.26	4.12	3.80	4.37	16.37
Dairy meal	1.66	25.36	3.17	28.57	90.88	12.64
Agri-byproducts	2.00	44.40	2.00	44.40	0.00	0.00
Compound salts	0.10	26.01	0.10	28.14	2.42	8.21
Stock salts	0.79	15.93	0.30	17.03	-62.40	6.91
Water (20lts)	37.99	0.87	38.42	1.85	1.14	112.63
	68.27	**130.69**	**71.57**	**144.51**	**4.8**	**10.6**

Kg= Kilogram %= Percent

cost the farmers incurred from buying feed in form of hay from other vendors. Cost of cut and carry forage went up due to handling and transport charges. Cutting and selling fodder from the forest has become an emerging economic activity where a group of mainly young men venture deep into the forest to cut and carry fodder for reselling to dairy farmers. They pay the government stipulated cost of 25sh per back load of harvested fodder to the forest guards (GoK. (2012). Forest act, Legal notice no. 104). This has contributed a lot to increase in cost of fodder around Eburu. Methods of feeding that involve harvesting (i.e. cut-and-carry systems) are more demanding in terms of labor, transport and storage facilities.

The price increase for crop residue could be due to crop failures in maize in the last two seasons before the survey leading to scarcity and farmers abandoning the crop. Feeds account for more than 60% of the total cost of production in dairy. The cost of feeds went up after the fence erection despite having fewer cows an indication that forest fencing contributed to the slump in the numbers of cows kept.

Insufficient water for both cattle and household consumption was a major constraint to most farmers. The cost had gone up by 112% per 20 liters during dry season. In some areas, farmers reported walking cattle for long distances (3-10 km) in search of water. Piped water and community water tank had an inconsistent supply, seasonal streams and shallow on-farm wells dried up during the dry season; water business emerged as a result. Harvested rain water and shallow springs and streams within the forest and emerging from the forest remained the main water source during the dry seasons. Generally farmers supplemented during the dry season and for those animals being milked. Some of the feed supplements used were hay, maize germ, wheat bran and dairy meal. There was an increase in use of compound mineral salts. Due also to high

population density, small land holdings supplementation with grown fodder and concentrates was reported by (Orodho, 2006) amongst small holder farmers.

3.4.5 Fodder management

Seasonality of forage availability impacted on nutrition and livestock management. To cope and mitigate on these effects, farmers made effort to conserve fodder using various methods. As a production system evolves into more intensive stall feeding, fodder conservation will be crucial for sustained feed availability. May to December was fodder plentiful months whereas January to April was the fodder scarce months. During months of plenty the body condition score improved and poor in times of scarcity. According to table 3.6 the method of fodder preservation mostly used was storage as standing fodder followed by conservation as hay. About 19 % of farmers used silage as a way of preserving excess fodder. A 3.8% of farmers did nothing and waited for the period to elapse and others sold the excess fodder, 76% of the farmers purchase feed to cushion against losses due to drought. Another 12.5% sold their animals. Fodder conservation is through harvesting, preserving and storing excess fodder. This reduces dependence on the forest fodder, incidences of forest fires in dry seasons, discourage farmers from grazing their livestock deep into the forest hence promoting under story growth and seedling germination.

January to April the driest months coincided with the period of highest fodder scarcity. Farmers were not restricted to access the forest and grazing extended deep into the forest up to 5km inside. Low milk production and high milk prices were reported during this period. Adoption of fodder conservation concept was low and farmers expressed the desire to be trained in conservation technologies such as box baling (Massawe *et al.,* 1998) or making tube silage (Methu and Mbuthia, 2005) to conserve feeds for dry season feeding.

Table 3. 6: Percentage of respondent farmers on their fodder conservation/mitigation techniques

During abundance		**During scarcity**	
Conservation	% respondents	Mitigations	% respondents
Hay	31.7	Purchase feeds	76
Silage	19.2	Sell animals	12.5
Standing fodder	39.4	Do nothing	3.8
Sell	1.0	Buy feeds and sell animals	2.9
Do nothing	8.7	Others	4.8

Majority of farmers' attitudes and perception on the impact of the fence varied as shown in table 3.7, 66.3% believed that it had led to reduced fodder availability and as a result affected dairy productivity. About 59.7 % and 64.4 % agreed that the fence has led to poor animal body condition and decreased milk production respectively. These two aspects could be attributed to decrease in fodder availability hence impacting on nutritional requirements of the dairy cows. Erection of the fence was also viewed as the reason for increased cost animal feed inputs and the shifting from extensive grazing to a more intense stall feeding production system by 66.3% and 69.2% respectively due to the increased cost of production. About 69.2% respondents agreed that this had led to increase in the price of milk. The two factors were related as there were low or zero costs on fodder prior to the fence. Despite all these negative perceptions on the fence, 54.8% disagreed that the fence had led to abandoning of dairy farming amongst forest adjacent communities with 69.2% of farmers reported to have agreed that the fence had led to increase on land acreage under fodder.

3.4.6 Conclusion

- Before Eburu forest fencing, dairy farmers had easy access to fodder and travelled shorter distances to collect fodder from the forest and
- There were little control on the number of animals entering the forest, the amount of fodder harvested and frequency of grazing or fodder harvesting from the forest.
- After the fencing, there was controlled access to grazing and fodder harvesting and restriction of goats into the forest to encourage seedlings re-growth.
- The fence resulted in increase in the amount and variety of fodder offered to the dairy cows because farmers established own fodder plots and bought/sold fodder into the location during dry seasons, or sold out during the wet season. Thus its price went up.

Table 3. 7: Respondent (%) perceptions of fencing on dairy production

Farmers perceptions					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Fencing has led to reduced fodder availability	9.6	18.3	1.0	66.3	4.8
Fencing has led to poor animal body score	3.8	26.0	8.7	59.6	1.9
Fencing has led to decreased cow average milk production	5.8	19.2	4.8	64.4	5.8
Fencing has led to increase in cost of feeds	4.8	14.4	2.9	66.3	11.5
Fencing has led to farmers reducing the number of cows kept	3.8	14.4	5.8	60.6	15.4
Fencing has led to some farmers abandoning dairy farming	14.4	54.8	7.7	16.3	6.7
Fencing has led to change in livestock production system from extensive to zero grazing system	5.8	3.8	15.4	69.2	5.8
Fencing has led to increase in acreage under fodder cultivation in own farms	0.0	9.6	15.4	69.2	5.8
Fencing has led to increase in cost of dairy products	3.8	11.5	8.7	69.2	6.7

CHAPTER FOUR

IMPACT OF FOREST FENCING ON DAIRY CATTLE PRODUCTION SYSTEMS; CASE OF EBURU FOREST MAU FOREST COMPLEX.

ABSTRACT

A 50km fence along the 8715.3 hectares legal boundaries of Eburu forest was erected to protect it from degradation. The fence restricted access of the forest by adjacent dairy farmers to grazing and cut-and-carry fodder. This study documented the changes in dairy cattle production systems among forest adjacent communities in Eburu occasioned by the fencing. A combination of household survey and participatory rural appraisal tools were used to collect data randomly from organizations and members of the communities living adjacent to the forest. The distance of the farm to the nearest forest gate was considered as an independent variable while forest access fee, access to fodder/fodder availability and number of livestock were taken as the dependent variables. From the study, there was a 64.6% reduction in the number of farmers grazing their animals in the forest. Access fee compliance was at 46.2%. At the same time there was a 66.7% increase in the number of farmers using stall feeding, shifting production systems from extensive to intensive. There was an increase of 18.2 % of the available land to dairy cattle production. The cost of labor for dairy activity went up, the number of exotic dairy cows decreased whereas the crosses increased. Farmers adopted better feeds and feeding strategy. Better forage regeneration was noted on previously overgrazed land. Thus fencing has greatly influenced dairy cattle production and land use systems pattern changes.

Key words: Eburu forest fencing, grazing, cut and carry fodder, forest, livestock production system, land use changes.

4.1 Introduction

Forest ownership is complex and characterized by overlapping rights due to social and ecological diversity and interactions between various groups and resources. Forest adjacent farmers depend on livestock as a source of livelihood. Mau Eburu forest block forms part of 22 gazetted blocks of the 420,000 hectare Mau Forest Ecosystem. It is the easternmost extension of the Mau range and forms part of the wider ecosystem stretching from Lake Nakuru, Soysambu, Lake Naivasha and Hells Gate (REF/ MAP).

Mau forest supports a large population of communities and their livestock, but its continued destruction by human activity exposed lives of more than 8 million people and their livestock to risk of drought hunger and loss of livelihood (Force, P. M. S. T. (2009). In the case of Eburu forest block, continued destruction and loss of biodiversity necessitated stakeholders, the Kenya Wildlife and Forestry services to enhance conservation measures. To this end, Rhino Ark Kenya and other stakeholders erected a 50 km electric fence around the forest on 23rd March 2013 (Mwangi, 2010). After the erection of the fence, access through the gates reduced forest fodder and water availability due to the fact that the gates were positioned 6 km apart reducing access to many farmers. The purely conservational fence negatively affected many forest adjacent communities who depended on the forest for fodder and water for their livestock among other such livelihood activities as fuel wood, grazing, charcoal making, bee keeping, and timber harvesting (Butynski, 1999; Castro and Nielsen, 2001; Pandey, 2011)

The livestock sector is socially and politically sensitive. It accounts for 40 percent gross domestic product and employs 1.3 billion people directly and indirectly and at same time creating livelihoods for one billion of world's poor (Seinfeld *et al*., 2006). Without taking account of value of home consumption of livestock products, livestock contributes 20 percent of household cash income at the Himalayas (Tuliahan and Nepean, 1999). At Eburu 99% of the farmers owned livestock and 77.9 % of these farmers depended directly on the forest for forage and or water for their livestock. Crop farming and livestock contribute to 78 % of their total household income compared to 76.4% after the forest fence. In Kenya, shortage of feed is one of the major limiting factors for better productivity of livestock sector (Methu *et al.,* 2001). There was therefore need for scientific information on the effect of the fence on the availability and cost of forest fodder. The study quantified these changes and their effects on dairy cattle production in Kiambogo location of Eburu forest with the aim of evaluating how the fence has affected fodder availability from the forest and how these changes have influenced the evolution of dairy farming around Eburu forest.

4.2 Materials and methods

4.2.1 Study area

4.2.2 Location and size

The study area is part of Eburu forest located in Nakuru county, Gilgil Sub-county, Kiambogo location, Kahuho and Dunyu Buru sub-location having populations 1060 and 920 people respectively (Kenya National Bureau of Statistics, (2009). Eburu forest is one of the 22 Eastern Mau blocks that cover 420,000 hectares. Having an area of an area of 8,715.3 hectares, the forest lies between longitudes 36° 05' and 36° 16' east and latitudes 0º 40'and 0º 41'South.The study area lies adjacent to the forest fence of prime indigenous forest. The fence has various accesses

point which serves as gates. The gates are placed within specific distances 6km apart from Kahuho gate to Morop power house.

4.3 Research tools

4.3.1 Questionnaire survey

The study was carried out in the month of March and April, 2014. A reconnaissance study was conducted and the questionnaire pretested. Respondents were asked a range of questions, including their holding of all types of private lands (including leased land on which they grow fodder), their level and source of food sufficiency, family size, household labor, livestock holdings, earnings from the livestock, other sources of income, and fodder from the forests. The respondents were also asked about the number of livestock the before and after fencing, the frequency or the length of time the farmer spent grazing in the forest, the amount of fodder harvested per day through cut and carry, milk productivity (liters), Household income from livestock, grazing or stall feeding, Forest access fee if charged among other factors. Also the dairy cow details, date of birth, method of entry and other production parameters were recorded (appendix 1 for questionnaire and record sheet). A total of 105 households were randomly selected from Kahuho and Ndunyu Buru within a five Kilometer distance from the forest fence.

The study used probabilistic sampling based on the population size (not household numbers) of the study area. The formula by Barlett *et al.*, 2001) was used to calculate the sample size;

$$n = \frac{(z^2 \times p \times q \times N)}{e^2 (N - 1) + (z^2 \times p \times q)},$$

Where n = Sample size (being determined)

N = Population size (known)

p = Sample proportion (assumed to be 0.05, if not given)

q = 1 – p

e = 0.05 (since the acceptable error (level of significance) should be 5%)

z = Standard deviation at a given Confidence interval (z = 1.96 at 95% CI)

Therefore;

Sample size for the study area with a total population of 1980:

$$n = \frac{1.96^2 \times 0.05 \times 0.95 \times 1980}{0.025(1980-1) + (1.96^2 \times 0.05 \times 0.95)}$$

$$= 70.43115$$

4.3.2 Key informant Semi-structured interview

The semi structured interviews were used to get in-depth knowledge on topics concerning livestock keeping and Eburu forest fencing from the key informants such as the forest officer, livestock officer, rhino ark official, Ogiek elder and bee keeper, CFA chairman and the chief. The topics to be discussed were varied depending on to the respondent and the information the study intended to obtain from them.

4.3.3Transect walk

An observational walk on people, their activities, resources and environmental features was done. The walks were used to verify data gathered from literatures, identify fodder and their distribution within and outside the forest. The transect walks were used to establish the gate distance between different livestock keeping households and time taken to trek looking for fodder to and from the forest.

On land-use, the transect walk focused on environmental and agricultural features (such as cultivated land, forests, the extent of the fence, type of livestock kept, livestock production systems, acreage under own fodder, streams, sources of water, types of crops farmed).

The data was recorded, summarized and scrutinized for inconsistency and then was exported to Statistical package for Social Scientists (SPSS version 16.0 2008) and MS Excel 2010 for further interpretation. The processed data was analyzed using descriptive statistics such as total, averages and percentages.

4.4 Results and discussion

The results of this study presents finding recorded one year after the fence was erected. It should therefore be noted some of the effects or changes recorded are still at a nascent stage and will be more significant after some years when all the control structures and systems will be in place and farmers adapted to the changes. These findings are indicative of developing and expected impacts of the fence.

4.4.1 Social economic characteristics of the households

Kiambogo village is dominantly home to the Dorobo, Kikuyu and Maasai people. Dorobo are forest dwellers, Kikuyus are farmers whereas the Maasai are traditional pastoralists. Land acreage range from 5-87 acres but the land has not been fully adjudicated from the previous Ol Jorai ADC farm (Eburru participatory forest management plan 2008-2012). Most families were male headed at 74 %. Ownership of the dairy cows was a male responsibility. The population of the youths 35 years and below was 13.5% and quite a big percentage of an older population. This population structure could affect dairy production as family was the main source of labour at 96.2% compared to 3.8% of hired labour. This because as the production system changes to more intensive stall feeding more labour will be required to harvest, process and feed the cows.

Almost 95% of rural forests adjacent communities depend in one way or another on at least one forest produce like firewood, medicinal plants, seedlings, grazing lands etc. (Langat and Cheboiwo, 2010). On average each household kept 3 dairy cows and depended on the forest for grazing, cut and carry or water. Most of the households were male headed but women were the ones directly involved with taking care of the cows. Other socio-economic aspects of the study area are as shown in table 4.1.

A source of income is important to adjacent families; sale of forest products contributes about 40-60% of household income (Kumar *et al.*, 2011) and thus offers employment to the many poor households. Due to widespread poverty, less land and lack of alternative sources of income, the FAC tend to over-exploit these resources (Reddy and Chakravarty, 1999).

Livestock and crop production were the main source of income as sown in figure 4.1. Others included salaries. Investments, sale of forest non-timber products, sale of fodder, charcoal and timber. There was a slight drop in the income from the livestock and crops after the fence compared to before the fence; this could be due to reduced fodder availability for livestock and maize lethal necrosis on crops.

Table 4. 1: Social economic characteristics of the respondents of Kiambogo location

Household characteristics	Description	Percent (%)
Respondent sex	male	74
	female	26
Age group	20-35	13.5
	36-45	12.1
	46-55	13.5
	56-65	28.9
	66-75	18.3
	>75	3.9
Livestock ownership		99
	Compliance -Yes	46.2
Access fee	No	53.8
Distance from forest	1Km	47.1
(Distribution of dairy farmers	2Km	27.9
From forest gate)	3Km	15.4
	4Km	4.8
	5Km	4.8
Labour	Family	96.2
	Hire labor	3.8

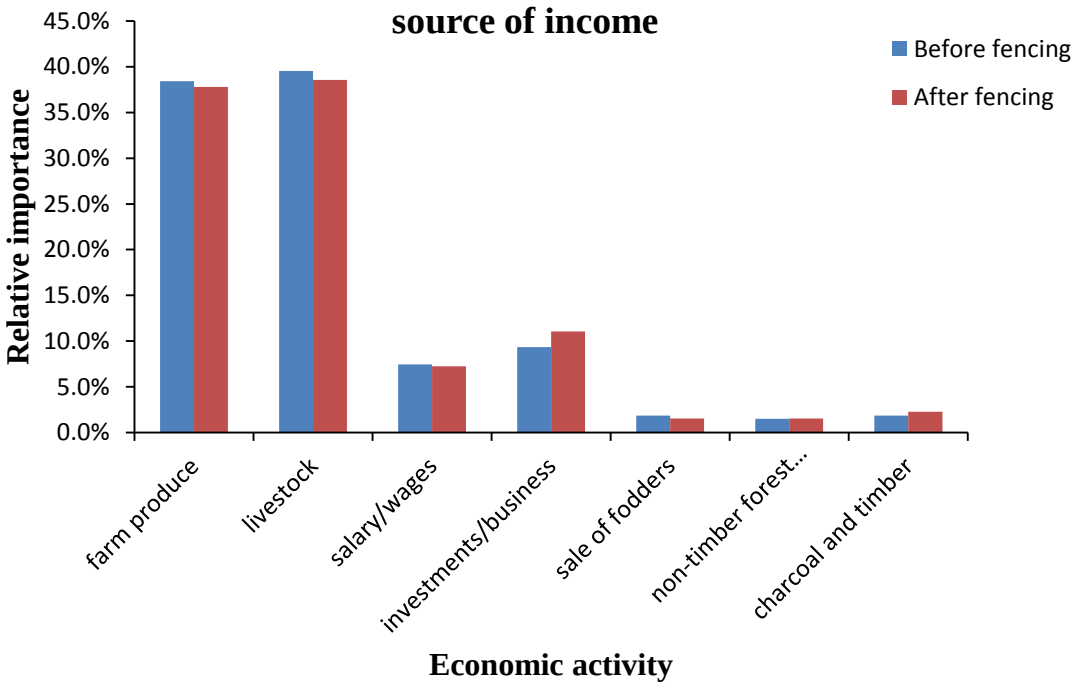


Figure 4. 1: **Economic activities and sources of household income before and after the fencing**

4.4.2 Forest access and user rights

Access is the right and ability to use common-pool resource such as forests. This can be influenced by physical or social factors. Physical factors mainly involves proximity to the common resource whereas social is one's social status within a society (Grima and Berkes, 1989; Baumann, 2002)

The access fee was payable by all farmers who utilized the forest for grazing or cut and carry fodder collection. From the respondents interviewed as shown in table 4.2, the distance and location of a household from the manned forest gate determined the ease at which a farmer could access and utilize forest resources. Unlike previously when the frequency, the amount of cut and carry fodder harvested was not as restricted. The number of livestock at each given time was also controlled whereas goats were strictly restricted.

Most of small holders across developing world depend on common lands for grazing to supply their livestock feed (Sandford and Ashly, 2008). According to (Ribot and Peluso, 2003), access is defined as "the ability to benefit from things including material objects, persons, institutions and symbols". It encompasses both entering into a defined physical property and obtaining products of a resource, in terms of access and withdrawal (Schlager and Ostrom, 1992). Feed and feeding practices among the respondents depended mostly on the farm distance from the nearest forest gate and the ease to access forest fodder. The study established that up to 50% of the farmers within 1 km radius from forest gate used mixed zero grazing and grazing, this number decreased as you moved away from the forest such that at 5km most farmers used zero grazing.

In Kenya, grazing in the forest is allowed in some instances on payment of a grazing fee of Ksh. 100 per cattle head and Ksh. 40 per sheep per month (Forest act, Gazette supplement no 132 legal notice no. 28th September 2012). The number and species of livestock were key factors

used to calculate the fee payable per household. The higher the number of animals the higher access fee levied. The rugged hilly terrain hindered farmer's easiness of entering the forest. The most forest adjacent dairy farmers were not very compliant yet they utilized forest resources. Their proximity allowed them to cut and carry fodder as opposed to grazing their animals into the forest because they covered shorter distances. Access fee compliance indicated a positive attitude towards the fence and acceptance of the conservation efforts. As one moved further away from the forest gate the compliance decreased showing a decline in forest dependence as the number of dairy cows decreased too.

Dairy farmers who harvested a backload of fodder were not charged and this concurred with (Studsrød and Wegge, 1995) finding that more forest adjacent households enjoyed more direct benefits compared to those households far from the forest.

Table 4.2 shows that farmers closer to the forest gate kept more livestock and this decreased as you move further away from the forest fence. These farmers also paid the highest amount of access fee. This could be attributed to the fact that they kept the most number of animals and also utilized more fodder from the forest compared to other farmers located far from the forest. Proximity to the forest gives then the advantage of shorter distances.

About 22.1% of farmers paid between 100-2000 Ksh per year to access the forest for fodder. Majority of these farmers were between 2 to 3 Km from the fence. About 11.5% paid between 2001-4000 Ksh per year and were found 3 Km from the fence. Another 7.7 percent of the farmers located 3-4km away from the fence paid between 4001-6000 Ksh whereas 4.8 percent of the farmers located 5km away from the fence paid more than 6000Ksh per year.

On compliance with paying the access fee 53.9% of the respondents did not pay the access fee, out of this 47.1 percent and 6.7 percent were 1 to 2 kilometer from the fence respectively.

Payments were not levied as stipulated due to logistical, enforcement and or payments mechanisms problems. Reasons for non-compliance included: fee considered excessive, local belief of their inherent right to graze in the forest, inconsistencies in levying (payment suspended during dry seasons) and some people live or carry legitimate activities in the forest for example the Ogiek community members who have setup beehives)

Households within 0-2km paid less access fee yet they kept the largest numbers of livestock. This was attributed to them being the first group to be settled in Kiambogo with an average family size of 6-8 members. This exerted too much pressure on available resources including land leading to fragmentation into smaller pieces hence less productivity thus low disposable income. The area being closest to the forest is very steep and hilly. Farmers 3-5 Km from the forest gate paid the highest access fee of 2789 Ksh on average yet they had fewer livestock compared to those between 0-2km. Lack of title deeds has hindered permanent or significant development or land use around this area. They are also near the Kiambogo shopping Centre where there is pressure for land to accommodate the growing shopping Centre.

At a radius of 5km from the forest gate, households kept fewer animals and their source of income was mainly from investments and businesses they operated at Kiambogo shopping center. Their social-economic status was much better compared to those households closer to the fence. This could be attributed to higher cash flow as they served as middlemen who sourced produce from farmers and sold it to outer markets such as Nakuru, Naivasha and at times even Nairobi.

The older generation owned a larger herd size of dairy cows, large land acreage and was more financially able to afford a dairy cow. The willingness of the older generation above 40 years of age to pay the access fee was due to the institutional memory of early years when the forest was

intact and the benefits they derived from it such as predictable rainy and planting season, enough fodder and grazing land, cool weather, running streams of small rivers emanating from the forest as discussed during focus group discussion. This changed when "outsiders" unsustainably over exploited the forest resources for commercial markets leading to destruction of the forest. The willingness was also due to the fact that they owned large herds of livestock and land acreage. The age group 20-40 years consists of younger people and less economically endowed. They view the forest as a resource to be exploited for their own benefit. The younger generation doesn't own a large number of the livestock and similarly did not experience or witness the beauty of the intact forest. As reported by community forest association chairman and forest guards, the younger people were more likely to access the forest illegally.

From the study findings, distance to the forest and social economic heterogeneity showed significant relationship with forest access and forest utilization. Households residing close to the fence extracted more forest resources and were more dependent on forest for their livelihoods whereas those located at longer distances are discouraged to collect and utilize forest resources (Kerapeletswe and Lovett, 2002).

Table 4. 2: Relationship between average livestock numbers, Forest access fee charged and distribution of livestock from forest gate

		Access fee charged (Ksh)			
Distance to forest gate	Number of livestock/household	100-2000	2001-4000	4001-6000	6001>
1km	8	56.5%	66.7%	50.0%	60.0%
2km	7	30.4%	8.3%	25.0%	20.0%
3km	9	13.0%	8.3%	25.0%	20.0%
4km	7	0	16.7%	0	0
5 Km	14	0	0	0	0

4.5 Labour and land use

The study showed that less number of hours and money was spent on grazing livestock after the fence than before the fencing. Table 4.3 shows that there was a 2.5 % and 8.4 % drop in the number of hours and amount spent for grazing respectively. With regard to feed collection and processing there was a 100% and 57 % increase in the hours spent respectively. Minimal changes were observed on the hours used to feed the cows but the cost of feed collection and feeding the cow went up by 74% and 96% respectively. The labor costs for grazing and went down by 8.4 % and 17% respectively as indicated in table 5.3. Dairy farming is labor intensive; activities involved include grazing, feed collection, feed processing and feeding cows. The family offered 94% of the labor required. Changes were noted in labor demand before and after fencing. Decrease in labor costs for grazing and feed processing and increase in cost of feed collection and feeding the cows indicate changes in livestock production system from extensive grazing to more intensive stall feeding system. These changes could be signs of future trends of livestock production systems to forest adjacent communities as impacts of forest fencing take shape.

Labour cost of feed collection from the forest and feed processing also went up after the fence, since a number of farms were isolated and distance covered to access the forest increased. This discouraged most dairy farmers from taking their animals into the forest for grazing and as a result the use of cut and carry fodder. The increase in cost of feed collection could also be attributed to many farmers practicing stall feeding. Fodder business was also on the rise, vendors harvested fodder from the forest and then sold it to dairy farmers thus partly reducing cost of feed collection but increasing the overall cost of feeding. Feed processing involved withering as standing or cut fodder, sorting and chopping the fodder into pieces appropriate to feed the cows.

Table 4. 3: Estimated labour costs per hour on various farm activities before and after fencing in Kiambogo village.

Farm activities	Before fencing		After fencing		
Farm Activities	number of hours	cost per hour (Ksh)	number of hours	cost per hour (Ksh)	Change in labor costs (%)
grazing	4.8	30	4.8	40	33.3
feed collection	1.2	47	1.9	67	42.6
feed processing	1.3	59	1.3	63.6	7.8
feeding cow	2.7	44.2	2.6	56.4	27.6

4.6 Land use

Eburu zone is mainly an agricultural area as the study confirmed. The total acreage of land for the interviewed households was 404.5 acres and the average land holding per household was 3.85 acres with the largest individual ownership being 15 acres.

Slightly above 50 % of land was put on food crop which include maize, beans, onions, wheat and cabbages. Most of these products were mainly for market and a small percentage for subsistence. Most of farming activities were mechanized using tractors. Only 6 % of the lands were used for cash crop and the main cash crop is pyrethrum. Due to challenges in the pyrethrum industry most farmers have deserted the crop to more lucrative horticultural crops such as cabbages, onions and dairy farming to supplement income. On average 20% of the total land equivalent was used for dairy farming activities which included land for fodder, pasture establishment and dairy housing. The main type of established fodder was nappier grass whereas Rhodes grass, Kikuyu grass, star grass and natural pasture were the main type of established pasture. As shown in table 4.4, there is an increase in land acreage used for dairy farming activities. After fencing, the change from extensive grazing to stall feeding increased the need for farmers to establish their own fodder in their private land. Land under pyrethrum, showed a slight decline due to farmers opting for more profitable food crops. The main food crop maize was attacked by a viral diseases called *Maize lethal necrosis* (MLN) the previous season therefore farmers reduced acreage under maize (*Personal communication with Gilgil Agricultural officer, 2014*). Adoption of agroforestry increased acreage under own forest. Clearing of forest land for settlement, led to extensive gully and wind erosion. Rhino ark as part of community participation, trained farmers on tree nursery establishment as a source of livelihood and also as a method of reclaiming eroded land (Rhino Ark, 2013).

Table 4. 4: Proportion of land allocation in acreage to various farm activities

Farm activity	Before fencing (acres)	After fencing (acres)	Percent change (%)
dairy fodder	0.24	0.3	25.0
dairy housing unit	0.19	0.22	15.8
dairy pasture	0.46	0.51	10.9
cash crop	1.8	1.75	-2.8
food crop	2.2	2.12	-3.6
own forest	0.3	0.31	3.3

4.6 Livestock production system in Kiambogo

This section outlines the main aspects of livestock production systems highlighting the level of intensification and various aspects of management.

Grazing was allowed into the forest before the fence without any restriction to the number or type of animal, frequency of entry as some farmers could let their animals graze in the forest for extended period. After the fence, there were manned forest gates, the distance and the access fee discouraged forest fodder utilization , goats were completely restricted from grazing into the forest, number of animals allowed into the forest to graze, number of grazing hours and even specific locations to graze were controlled. All these factors led to decrease in fodder available. To adjust, farmers selected breed of animals, adjusted their herd structure, modified their feed and feeding strategies, changed their production system and increased land under own fodder. Body weight change is a factor of fodder availability, animal health and production system. In stall feeding the animal nutrition is constantly monitored and supplementation can easily be done, the animal does not walk for long distances in the hilly topography and thus conserve the energy for maintenance and production. Stocking density is also an important component especially where feed resources are scarce or restricted. Over stocking will lead to under or malnutrition thus poor body condition for the animals, it will also cause environmental degradation through soil erosion, soil compaction, trampling of seedlings and breaking of tree branches.

Seasonal changes in numbers of animals grazing into the forest were noted corresponding to dry or rainy season. During dry season, there was a sharp increase in the numbers of local cattle is attributed to the Maasai who migrate into Kiambogo area looking for water and pasture in the forest. During rainy season few animals graze into the forest as there is plenty of fodder in own

farm, communal grazing lands and roadside grazing. Sheep and goats number also dropped due to fodder pressure (Mr. Kirui, Community Forest Association Chairman, 2014).

The demand for an alternative source of forage led to sale of fodder as an emerging business. Groups of people have organized themselves, to harvest fodder deep into the forest and sell it to dairy farmers. Their selling price depends on fodder quality, quantity, type of fodder and prevailing weather and market conditions (demand and supply; during drought/dry seasons the prices goes up and vice-versa).

Poultry farming especially improved local chicken and commercial meat birds were on the rise. This offered farmers a new source of revenue that is less capital intensive, requires less space, does not directly depend on the forest and is market oriented. The closeness to Kenya Agriculture and Livestock Research organization (KALRO) Naivasha also contributed a great deal to the high uptake of improved local chicken.

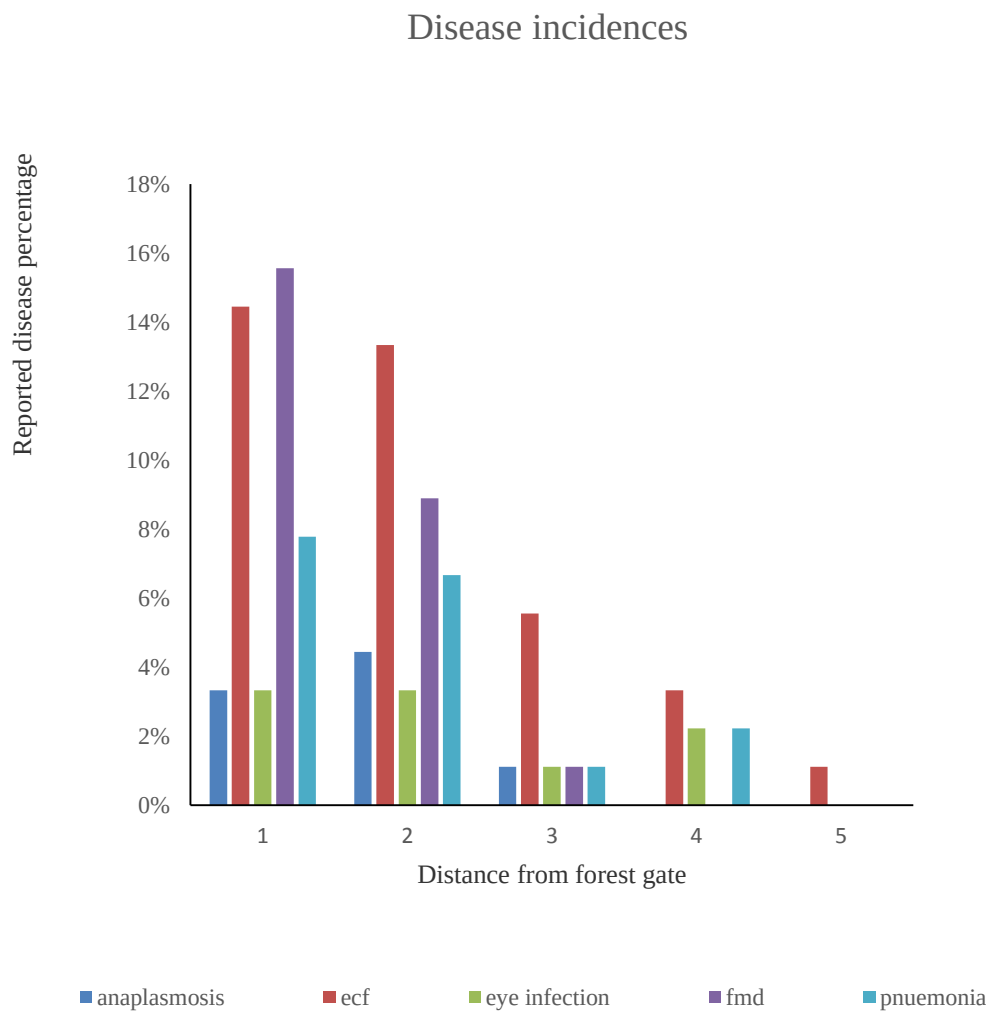
According to the respondents interviewed, at one km half of the farmers grazed and stall fed their animals before and after fencing whereas 33.3 % of farmers zero grazed before fencing and 38.1 % practiced zero grazing after the fencing. The number of farmers who tethered their livestock decreased from 39.1 % before fencing to 35.3 % after fencing. At 1 km, no significant change was noted before and after fencing. Their proximity to the forest gate made it easy to graze in the forest than to incur an extra cost of stall feeding table 4.5.

The herd structure was composed of mostly adult cows, heifer calves, bulls and bull calves. The average milk production was 4.3 liters per day which is low, attributed to inadequate feeding of the dairy cattle. Diseases reported were Foot and mouth disease 25%, East coast fever 37%, Anaplasmosis 9%, un-specified pneumonia 19% and metabolic conditions such as milk fever at

10% as shown in figure 4.2. Table 4.6, shows that, 48% of the cows kept by were Friesians and their crosses followed by Ayrshires and Jerseys at 18.5% and 17.4% respectively. Forty six percent of the diseases were recorded on Friesians and their crosses followed by Ayrshires and Jerseys and their crosses at 18%. This could indicate that the breeds are more susceptible to local diseases and not well adapted to the local environment compared to the local cows. The movement of Maasai cattle into the area during dry season led to interaction between domestic animals grazing in the forest and due to poor animal health facilities and personnel there was

Table 4. 5: Proportion of respondents (%) on livestock production systems before and after fencing (In percentage)

Livestock Production System								
	All grazing		Grazing with stall feeding		Zero grazing		Tethering	
Distance	before fencing	after fencing	before fencing	after fencing	before fencing	after fencing	before fencing	after fencing
1km	53.2	76.5	50.0	50.0	33.3	38.1	39.1	35.3
2km	29.8	23.5	18.2	25.0	33.3	28.6	30.4	32.4
3km	10.6	0	31.8	25.0	16.7	23.8	8.7	8.8
4km	2.1	0	0	0	8.3	4.8	13.0	11.8
>5km	4.3	0	0	0	8.3	4.8	8.7	11.8



ECF: East coast fever FMD: foot and mouth disease

Figure 4. 2: reported disease cases

Table 4. 6: Proportion of various breeds and performance indicators

Breed	Breed composition (%)	Milk yields(Kg/day)	Age at first calving	Reported disease cases before fencing
Friesian	27.5	6	28	23
Friesian cross	20.6	4	32	19
Ayrshire	6.3	5	35	4
Ayrshire cross	12.2	3	36	13
Jersey	11.6	3	25	8
Jersey cross	5.8	3	34	8
Local cow	8.5	4	46	10
Sahiwal	0.5	3	36	1
Sahiwal cross	2.6	4	41	2
Boran	1.1	6	35	1
Boran cross	3.2	4	31	2

high incidence of diseases (focused group discussion). The communal dips were not working or maintained.

The study established that the average age at first calving was 30.2 months table 4.6; the same was noted by (Odima, (1993) in his study in reproductive indices around Kiambu district. There was poor recording of both heat dates and return to heat dates and calving intervals. The cases recorded showed a long inter-calving interval of up to 36 months. Poor reproductive performance is mainly due to poor feeding, slowing down growth delaying puberty which subsequently led to an older average age at first calving same and as silent heat.

4.7 Conclusions

From this study, we noted that the fence has affected livestock production systems and land use within communities living adjacent to Eburu forest. Due to these changes the cost of production increased marginally but the income from increased milk sales and fertility had a greater economic impact to those who adapted to the changes. The shift in change from extensive grazing to semi-intensive and intensive reduced pressure on the forest and allowed fodder regrowth. With increase in feed given to the dairy cows the body conditions of the cows greatly improved. With improved body score milk production and fertility also improved resulting in better income to the farmer thus further reducing on over reliance on the forest as a source of livelihood.

With the fence, cases of livestock-wildlife conflicts, human-wildlife conflicts, and corridor diseases incidences were reduced. Through social involvement, Rhino ark also built water points and trained farmers on water conservation.

The fence led to changes in production system which with time will increase milk yields and cow productivity. These changes include increase in land acreage under own fodder, improved breed selection, improvement in dairy production techniques, improved animal nutrition and fodder conservation methods.

The study also revealed that there were loopholes in enforcing access to the forest. It's suggested that the community forest association and dairy user group should be strengthen in order to carry out this task. Policy makers should make legislations that incorporate the indigenous knowledge of local farmers in their conservation policies (Koech *et al.*, 2009)

CHAPTER FIVE

GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 General discussion

This study evaluated the effects of the electric fence towards fodder availability and by extension the impact on livestock production especially dairy farming amongst the forest adjacent communities around Eburu forest. The fence establishment was a culmination of many conservation efforts initiated by the local community, provincial administration and NGOs. Fruits of the efforts were already visible in terms of forest regrowth especially of the undergrowth and streams flow was on the increase. Households living adjacent to the Forest depended highly on forest resources for their livelihoods. They acknowledged that forest resources are beneficial and add value to their lives because they are able to supplement their own their resources (Kumar *et al.*, 2011).

The study established that, changes in fodder availability and production system mainly depended on the distance and topography of the farm to the forest gate, the number, the breed of dairy cow and type of livestock the farmer kept, land size, seasons or weather patterns, association with the community forest association and the ability to pay access fee.

Farmers at <1-3km had eased access to forest resources such as water and fodder more than those located >4km. The shorter distances made it possible to frequent the forest more to collect fodder or graze their animals. Due to this, majority of the farmers practiced semi-intensive systems where cows were grazed with little or no supplementation. As you move away from the forest gate, dairy farming was more intensive with farmers adopting to stall-feeding with mineral salts and feeds supplementation. This could also be attributed to change in breeds of cattle from indigenous to exotic and exotic breed's crosses that are not well adapted to walking long

distances. Farmers also paid more for cut and carry fodder from commercial vendors. The average number of cows per household was also higher. The topography also influenced access to fodder. Farms which were situated in areas with steep gradients and previously had a direct access to the forest had now been alienated, had to follow a long path in order to reach the forest gate. This discouraged them from engaging in dairy farming.

As forest fodder decreased, farmers adjusted by establishing their on farm fodder units. This was guided by the total acreage and the number of livestock. The larger the land size, the higher the acreage apportioned to dairy farming. Decrease in yields of maize due maize lethal necrosis also saw farmers allocating more land to fodder production.

5.2 General conclusion

The fence has led to changes in, fodder availability, livestock composition and production system that has increased milk production, household incomes and reduced their reliance and pressure on the forest. The significance of dairy farming as an alternative livelihood activity and source of income to the FAC has increased.

On land use, more farmers are growing their own fodder, establishing their own forest, assigning more land acreage to dairy activity and planting for two seasons in a year. These activities have improved the farmers general income and thus reduce their over reliance on the forest resources as a source of livelihood.

5.3 Recommendations

1. Fodder harvesting inside the forest should be managed to allow regrowth and all year round availability.

2. Since The Fence can impact positively on FAC livelihood, inclusive decision making is required to manage the forest grazing sustainably.

Scope for further work

The study was conducted one year after the fencing project completion therefore most of the expected changes or effects had not been fully manifested. There is need therefore to carry out studies on long term effects of the fence on fodder availability and livestock production.

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APPENDIX

Appendix 1: Questionnaire

EFFECT OF FENCING ON DAIRY CATTLE PRODUCTION AND LAND USE: CASE OF EBURU FOREST KENYA.

Introduction

- This information is strictly confidential and will only be used for the purpose of this study.
- Answer as accurately as you can remember.

Objectives

The overall objective of this study is to determine the effect of fencing Eburu forest on fodder/grazing areas availability and its consequences to dairy cow production systems and land use within communities living adjacent to the forest.

Respondent profile and farm identification

1. Questionnaire serial No. …….
2. Enumerator's name: ……. Code……
3. Respondent name:…….age…….sex ☐ M ☐ F
4. Is the respondent the head of this household: ☐yes ☐No
5. If not, what is the relationship to the head of household?
   ☐ Husband ☐ wife ☐son ☐daughter ☐farmworker ☐others…….
6. Have you had dairy cows in the last 12 months ☐yes ☐No
7. What is the distance of the farm to the forest gates?

0-1Km	
2-3 Km	
4-5 Km	
More than 5 Km	

HOUSEHOLD STRUCTURE AND FARM LABOUR USE

8. Who performs the following farming activities on the farm? (tick where relevant)

Before Fencing				**After Fencing**		
Activity	Family	Hired Labour		Family	Hired Labour	
		No. of hours			No. of hours	Cost/ hour
Grazing						
Feed collection						
Processing feed(chopping)						
Feeding cows						

HOUSEHOLD LAND OWNERSHIP AND USE

9. What is the total land acreage owned by the household?.....acres
10. Of the total land owned, how many acres is under:

Economic activity		**Before fencing**	**After fencing**
Dairy farming	Fodder		
	Housing unit		
	pasture		
Cash crop			
Food crop			
Forest (silvoculture)			

HOUSEHOLD SOURCES OF INCOME

11. What are the most important sources of income in your household?
(Rank from 1=most important to 7=least important)

	Before fencing							**After fencing**						
Source	1	2	3	4	5	6	7	1	2	3	4	5	6	7

Farm produce														
livestock														
Salary/wages														
Investments/business														
Sale of fodder														
Non-timber forest products														
Charcoal and timber														

LIVESTOCK INVENTORYAND HERD STRUCTURE

12. What type of livestock do you keep on the farm?

	Before Fencing		**After Fencing**	
Species/type	Total numbers	Average weight	Total numbers	Average weight
Exotic dairy				
Dairy crosses				
Local cattle				
Sheep				
Goats				
Donkeys				
Table eggs birds				
Meat birds/broilers				
Improved local chicken				
Local chicken				
Pigs				

13. What is the dairy cattle herd structure of your livestock?

I. Give numbers in each category

	Mature livestock				**Young livestock**			
	Breeding females	Breeding males	Non-breeding males	Non-breeding females	heifers	Bulls	Heifer calves	Bull calves
Total								
Average weight								

14. What livestock management/production system do you practice on your farm? (Tick the relevant system)

Dairy cows	**Before Fencing**	**After Fencing**
All grazing		
Grazing with some stall feeding		
Zero grazing		
Tethering		
Others (specify)		

LIVESTOCK FEEDS AND FEEDING PRACTICES

15. Enumerate the feed types and amount offered per cow/day on your farm.

Class of feed	**Types (specify)**	**source**		**Amount (Kg as fed)**		**Price per Kg**	
		Forest	Own farm	Before fencing	After fencing	Before fencing	After fencing
Roughages	Local pasture grass						
	Fodder grasses						
	Cut and carry fodder						

	Crop residues						
concentrates	Purchased dairy meal						
	Homemade concentrates						
	Agro-industrial byproducts e.g. wheat bran						
Mineral salts	Purchased compound salts						
	Stock salts						
Water							
Others e.g. Poultry droppings, banana pseudo stems, potato vines	1.						
	2.						
	3.						
	4.						

16. Which of the following are major constraints to livestock feeding on your farm?
(Rank follows: 1=always a problem; 2=only a problem seasonally; 3=not a serious problem)

Constraint	1	2	3
Shortage of basal feed			
access restriction to forest fodder			
Distance from forest gates			
High cost of purchased fodder			
High cost of concentrates			
High cost of casual labour			

17. In which months of the year do you experience:

	Surplus fodder	Scarce fodder		Surplus fodder	Scarce fodder
Jan			Jul		

Feb			Aug		
Mar			Sept		
Apr			Oct		
May			Nov		
Jun			Dec		

18. What do you normally do when you have excess feed on your farm?

☐Conserve as hay ☐conserve as silage ☐sell ☐do nothing ☐others specify

19. What do you normally do when you have shortage of feed on your feed?

☐Purchase feed ☐sale some animals ☐do nothing ☐other specify

EFFECTS OF FENCING

To what extent do you agree with each of the following statements on the effects of fencing? Please indicate your answer using the following 5-point scale where:
1. = Strongly disagree (SD) 2. = Disagree (D) 3. = Neutral (N) 4. = Agree (A)
5. = Strongly Agree (SA)

		SD	D	N	A	SA
20	Fencing has led to reduced fodder availability					
21	Fencing has led to poor animal body score					
22	Fencing has led to decreased cow productivity					
23	Fencing has led to increase in cost of feeds					
24	Fencing has led to farmers reducing the number of cows kept					
25	Fencing has led to some farmers abandoning dairy farming					
26	Fencing has led to change in livestock production system from extensive to zero grazing system					
27	Fencing has led to increase in acreage under fodder cultivation in own farms					
28	Fencing has led to increase in cost of dairy products					

29. Finally mention the most important impact of the fencing to dairy farmers and how in your opinion the change could be addressed

……

……

Thank you very much for you time.

Appendix 2: Cow details register

FOREST FENCE IMPACT ON ACCESS TO FODDER AND DEVELOPMENT OF DAIRY PRODUCTION: CASE OF EBURU FOREST KENYA.

Cow identity	breed	Date of entry	Method of entry		Age 1st calving	Last calving date	This calving date	Calf sex	Milk yield	Body condition score	Last heat date	This heat date	Last disease record	treatment
			birth	purchased										

COW DETAILS REGISTER FARM IDENTITY/OWNER …… DATE ……/……/……