Integrating climate Smart Agriculture interventions in small holder dairy feed value chain in Githunguri & Ruiru Sub-County, Kiambu County, Kenya

van hall larenstein
university of applied sciences

Tittle

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"This research has been carried out as part of the project "Climate Smart Dairy in Ethiopia and Kenya" of the professorships "Dairy value chain" and "Sustainable Agribusiness in Metropolitan Areas".

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specialising in
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Dedication

This work is dedicated to the Almighty God for comfort and strength he gave me to pull through this Master course without any critical disturbances. Also, to my virtuous wife Memory, our two sons Michael and Emmanuel for support, sacrifice and resilience shown during my absence.

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Abbreviations:

AGRA	Alliance for Green Revolution in Africa
CA	Conservation Agriculture
CCAFS	Climate Change, Agriculture and Food Security
CH_4	Methane gas
CO	Carbon monoxide
CO_2	Carbon Dioxide
CSA	Climate Smart Agriculture
CSD	Climate Smart Dairy
DLEO	District Livestock and Extension Officer
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
GDFCS	Githunguri Farmers dairy Cooperative Society Limited
GDP	Gross Domestic product
GHG	Green House Gas
ILRI	International Livestock Research Institute
KBS	Kenyan Bereu of Standards
KES	Kenyan Shillings
NAMA	National Environment Management Authority
N_2O	Nitrous Oxide
SACCOs	Savings and Credit Co-operative Society
SHDF	Small holder dairy farmers
VHL	Van Hall Larenstein University of Applied Sciences

Summary

Climate change has caused dilapidation of the environment, droughts and floods leading to reduced yields, productivity and ultimately food insecurity for human consumption. Unfortunately, it is our contact with the environment that has led to all this, but most people are not aware. The three gases contributing much to greenhouse gas emissions include nitrogen, methane and carbon dioxide. Hence this research focused on unravelling farmer's knowledge on climate smart agriculture, his performance on the dairy feed production and how he can mitigate greenhouse gas emissions. The goal is to evaluate how we can integrate best agronomic practices in feed production.

The main problem is insufficient production of quality dairy feed. The main causes are; Inadequate land size, low herbage production, inexplicit land tenure system, low soil fertility and expensive feed supplements. The main effects are increased use of fertilisers, increased methane production and reduced seasonal milk production leading to increased green-house gas emissions and reduced farmer income. The problem owner is Van Hall Larenstein University of Applied Science.

Smallholder farmers in Githunguri and Ruiru are producing milk on very small pieces of land. They are concentrating more on production because they are not aware of the implications of heir action on climate change. They need the information and knowledge on appropriate climate smart agriculture practises, technologies, institutional innovations and performance in order to integrate climate smart agriculture in dairy feed production. Tis thesis assesses integration of climate smart agriculture in Githunguri and Ruiru feed value chain for feed security at household level.

The project has a value chain approach. Initially we had a focus group discussion with the farmers. We then identified agronomical practices, climate smart agriculture technologies and practices that they are doing on their plots. These were then used to analyses climate smartness of their plots. Secondly, we had to make a selection of routes that were representative of the whole Githunguri area for selection of farmers from those routes. 5 routes out of 10 routes were selected for data collection in Githunguri. Snow ball sampling was done in Ruiru sub-county to come up with the farmers for data collection. We used household survey data, complemented by qualitative information from focus group discussions and key informant interviews. Case study was also conducted on plots for gross margin analysis of feed production.

The results show that there are notable differences between Githunguri and Ruiru sub-counties. Most of family labour is being provided by women. However, women and youths are marginalised in decision making o the dairy units. Youth participation is below 14%. The plot sizes are small averaging 1.6 acres. The number of dairy cattle average 7 and 3 for Githunguri and Ruiru respectively. The agronomic practices include agroforestry, minimum tillage, zero grazing, crop rotation, water harvesting, manure management, energy usage and soil analysis. We noted farmers are focusing on productivity of fodder and giving less concentration to climate smart agriculture. We also noted that the Githunguri dairy farmers cooperation is managing to provide services to farmers and it has a legal contract with farmers. It is a critical entry point to cooperative climate smartness.

Hence the project gave some recommendations on how farmers can integrate climate smart agriculture in their dairy feed value chain whilst still increasing production.

Chapter 1. Introduction

Kenya has a vibrant dairy industry with an estimated value of 3.5% to 4.5% of the gross domestic product (GDP) or 40% of the livestock sector GDP. It provides employment to over 1.2 million citizens. In 2014, the value of exported milk and dairy products was worth KES 1 billion. There are over 1.8 million smallholder milk producing households who own one to three cows, which in aggregate is over 80% of the national dairy herd (4.2 to 6.7 million cattle) (KDB, 2015). Kenya has the highest per capita milk consumption (110 litres) in sub-Saharan Africa, the equivalent of 5.2 billion litres a year. The bulk of milk (ca. 70%) is un-chilled raw fresh milk and sold to consumers through informal market channels (KDB 2015). This dairy sector prosperity is hinged on quality feed supply since feed constitutes 70% of total costs (Gerber *et al*. 2013). Thus this research will be focusing on the feed value chain.

Smallholder sector hold huge livestock population of 181.2 million heads which are currently underperforming due to unavailability of sufficient high-quality feed and costly quality feed supplements which are the central components of dairy project productivity for improving milk yields and hence dairy income for smallholders through intensification of smallholder dairy systems (Ayantunde et al, 2005; Mapiye et al, 2006). The high stocking density and scarcity of land leads to challenges of obtaining sufficient and good quality fodder, and recycling of manure as a fertilizer. Quality feeds are primary determinants of efficient dairy animal performance and productivity which influences greenhouse gas emission. Thus, integration of climate smart practices will ensure sustainable production of quality fodder on the available piece of land. These practices will also ensure mitigation of greenhouse gas emissions.

Poor feeding practices and unbalanced feed rations can lead to sub-optimal milk production and reproductive performance, increased feed costs per kg milk, and increased greenhouse gas emission intensity. Included in feed production, the expansion of pasture and feed crops into forests accounts for about 9 percent of the sector's emissions. Cutting across categories, the consumption of fossil fuel along the sector supply chains accounts for about 20 percent of sector emissions (Gerber et al, 2013). Manure storage and processing represent 10 percent. The remainder is attributable to the processing and transportation of animal products. So, for sustainable economic and profitable dairy business feed quality is critical and this can be ensured by climate smart agricultural practices. Hence, the need to integrate the practices in feed value chain.

Therefore, a solution which increases dairy feed production whilst eliminating greenhouse gas emission is sought after i.e climate smart agriculture practices in feed production that best suits resilient climate change mitigation measures. Hence there is need of assessment of climate smart practices that profitably and sustainably increase dairy feed production with a reduction in greenhouse gas emissions. FAO estimates that by applying practices with the lowest emission intensity, emissions could be reduced by 18-30% without reducing overall output (Gerber et al. 2013). Mitigation measures include increasing productivity and efficiency of feed resource use; conserving natural resources; and promoting development and consumption of climate smart dairy feeds in addition to proper business modelling.

1.1 Case study area

The study will be carried out in Githunguri and Ruiru Sub-counties of Kiyambu county. Both counties are serviced by Githunguri Dairy Farmers Cooperative Society (GDFCS). GDFCS is a farmer owned organization located in Githunguri with 76 milk collection points, 6 cooling centres and 58 retail outlets throughout their catchment. The cooperative has 25,936 members delivering an average of 230,000kgs per day. The catchment area has been divided into 10 routes for easy accountability of milk collection, trainings and services delivery. Their milk processing plant is located in Githunguri sub-county. Farmers in Ruiru sub-county deliver milk to their nearest collection centre in Githunguri and they come to Githunguri for any services related to the cooperative.

Most farmers depend on rainfed agriculture for pasture growth hence intermittent and erratic rainfall paralyses their cereal and pasture harvests leading to insufficient dairy feed. Climate change has instigated all these effects. Climate change changes the grass species and fodder composition (and hence biodiversity and genetic resources) of grasslands as well as affect the digestibility and nutritional quality of forage (Thornton *et al.* 2009). To cub fodder deficiency, farmers are applying fertilizers during feed production to increase yield. Fertilizer usage has also been increased because of low soil fertility. However, this intervention has augmented greenhouse gas emissions. Fodder deficiency has therefore forced small scale farmers to outsource fodder. However, outsourcing supplementary dairy feed is not economical at small scale. Thus, there is need for sustainable dairy feed production methods well adapted to changing weather conditions. In addition to that, continuous dependency on finite natural resources causes over exploitation of natural resources hence the need to implement climate smart dairy feed production methodologies and design business models that helps reduce greenhouse gas emissions, environmental and climatic impacts. This is the focus of this research project commissioned by Van Hall Larenstein University of Applied Science.

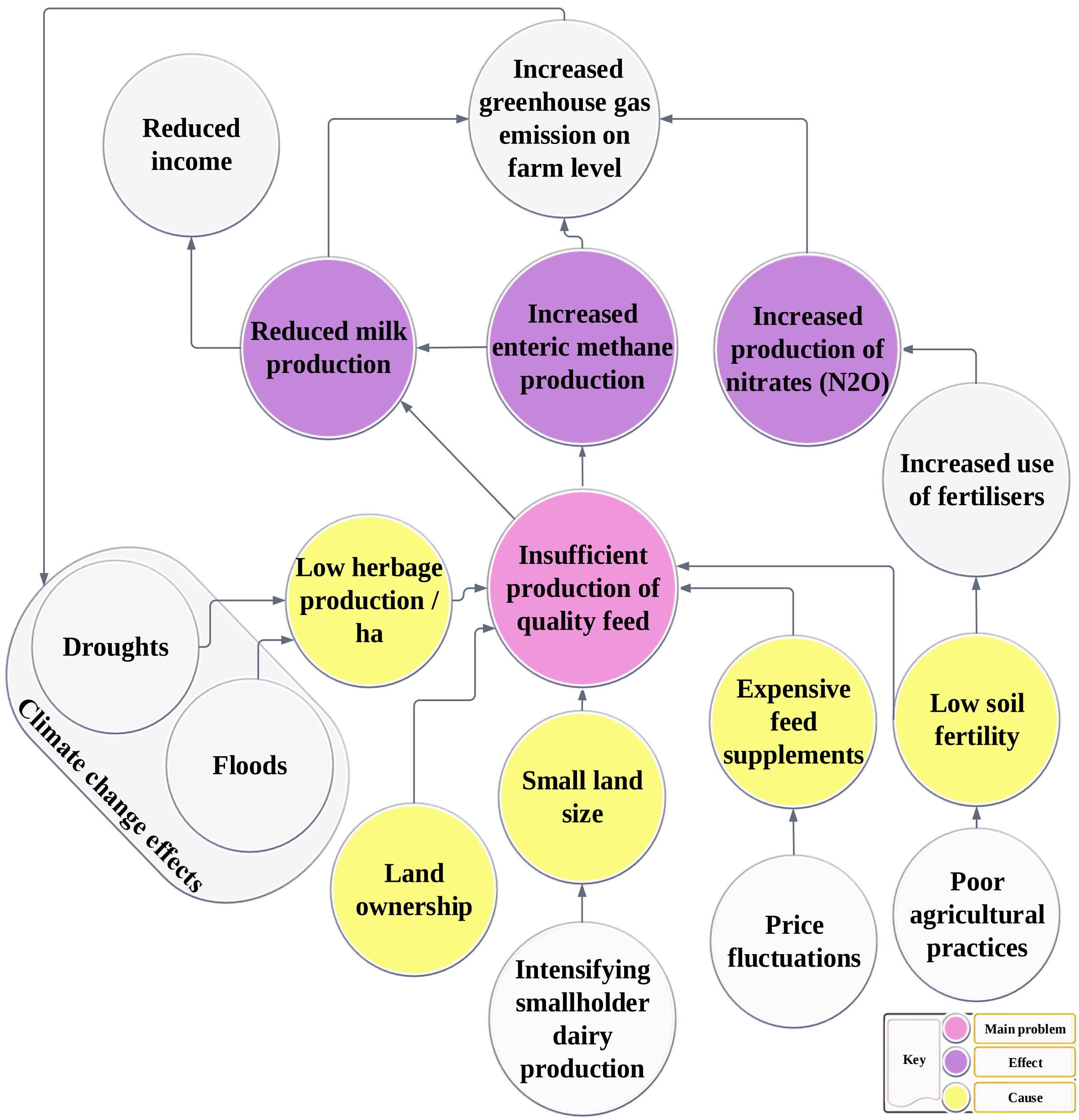
1.2 Case study commissioner

Van Hall Larenstein University of Applied Science is involved in a research project of "development of Inclusive and climate smart business models in Ethiopia and Kenya dairy value chains". The research is connected to the CCAFS project "Nationally Appropriate Mitigation Actions" (NAMA) for Dairy Development in Kenya to reduce GHG emissions from dairy production. The objective of this research project is to describe business models of chain actors and identify opportunities for scaling up good climate smart practices (https://www.nwo.nl/en/news-and-events/news/2017/wotro/2017.09.26-gcp-grants.html). Despite initiatives in the dairy sector, scaling up of good practices is lagging. Hence the need to research on dairy feed, the most important element of livestock production systems, forming up to 70% of the cost of production (Gerber *et al*. 2013). Smallholder dairy feed production climate smart practices that will lead to increased dairy feed availability whilst reducing greenhouse gas emissions will therefore be the research focus.

1.3 Problem statement and justification

The main problem is insufficient production of quality dairy feed as shown in figure 1. The main causes are; Inadequate land size, low herbage production, inexplicit land tenure system, low soil fertility and expensive feed supplements. The main effects are increased use of fertilisers, increased methane production and reduced seasonal milk production leading to increased green-house gas emissions and reduced farmer income. The problem owner is Van Hall Larenstein University of Applied Science.

Figure 1: Problem tree



1.4 Research objective

To identify best Climate Smart Agriculture practices that will contribute to designing of efficient small holder dairy farmer's feed production business models that favour reduction of greenhouse gas emissions.

1.5 Research questions:

1. What are the key characteristics of Githunguri and Ruiru small holder dairy feed value chain?

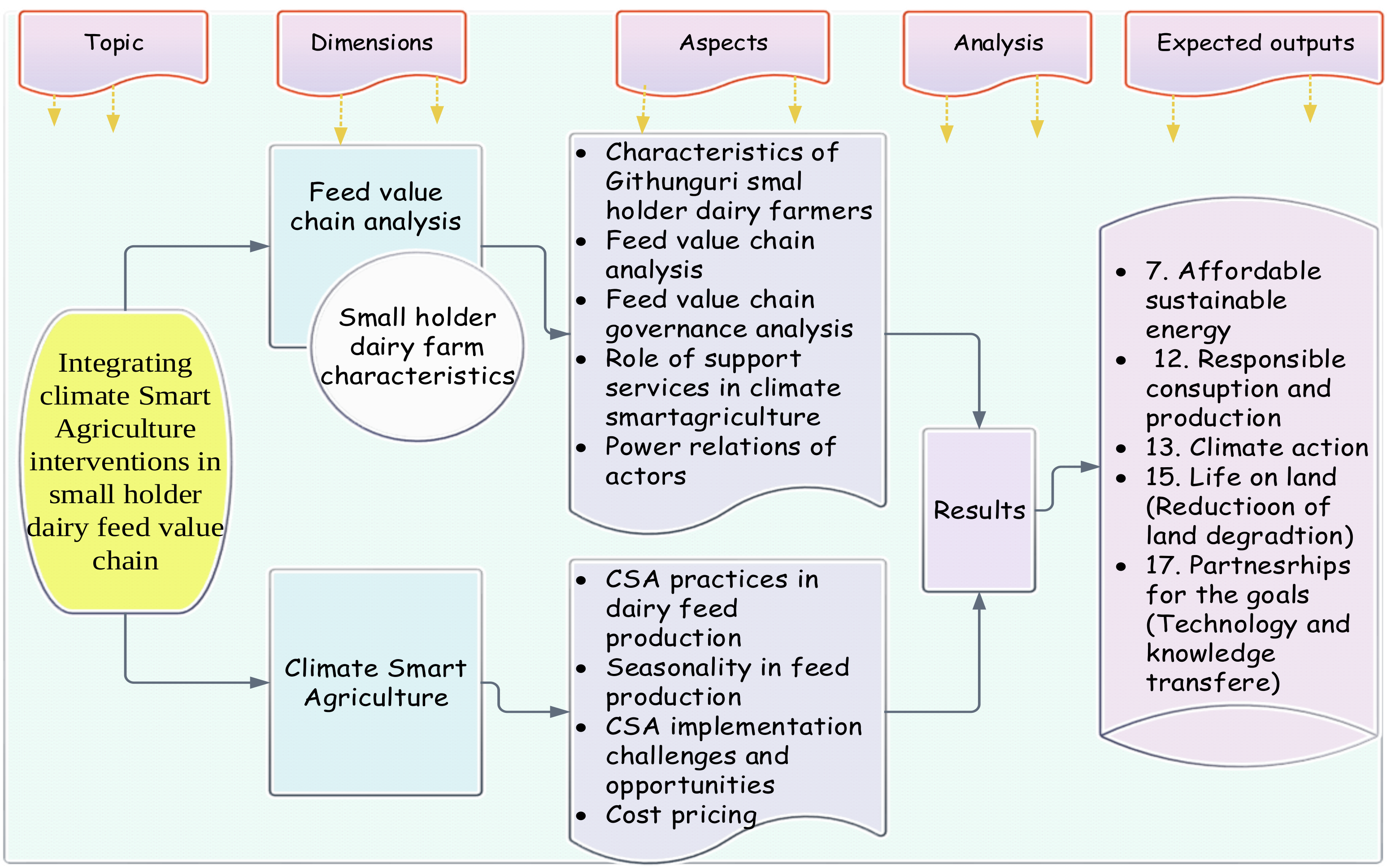
i. What are the characteristics of Githunguri and Ruiru small holder dairy farmers?
ii. What are the governance characteristics of feed value chain?
iii. What is the cost price and profitability of fodder production?
iv. What role is support services partaking in climate smart agriculture information sharing?

2 What are the opportunities to upscale dairy feed production whilst decreasing greenhouse gas emissions?

i. What are the climate smart dairy farming practices implemented on the farms?
ii. What is the seasonality of farm feed production?
iii. What are the potential efficient business models for climate smart fodder production?
iv. What is the potential of the Githunguri Dairy Farmer's Cooperative Society to introduce new and more efficient climate smart dairy farming practices in small holder dairy feed production?

1.6 Conceptual framework

Figure 2: Conceptual framework



Chapter 2: Climate smart agriculture synergy with feed value chains

This chapter is based on literature review.

2.1 Small holder dairy production

Globally, the livestock sector is a significant source of livelihoods, contributing to employment of at least 1.3 billion people and directly supporting 600 million smallholders in developing countries (Herrero et al. 2009). The Kenyan dairy industry is private sector driven and is the largest agricultural sub-sector that contributes 4% to GDP (MoALF, 2012). The sector provides nutrition, income and employment for approx. 1.8 million people across the dairy value chain: farmers, transporters, traders and vendors, employees of dairy societies, milk processors, input suppliers and service providers, retailers and distributors. The sector is dynamic with high annual growth of domestic milk production (averaging 5.3%), the processing capacity (averaging 7%), annual milk consumption per capita (averaging 5.8%) and a huge potential for export (KDB, 2015). According to the Kenya Dairy Board (2012) about 80% (approx. 5 billion liters in 2011) of Kenya's total milk production is produced by smallholders. There are currently 28 milk processors in the country, however 85% of 1.5 million kilograms of the milk processed daily is controlled by the big five processing companies which include Brookside, New KCC, Daima, Githunguri, Meru.

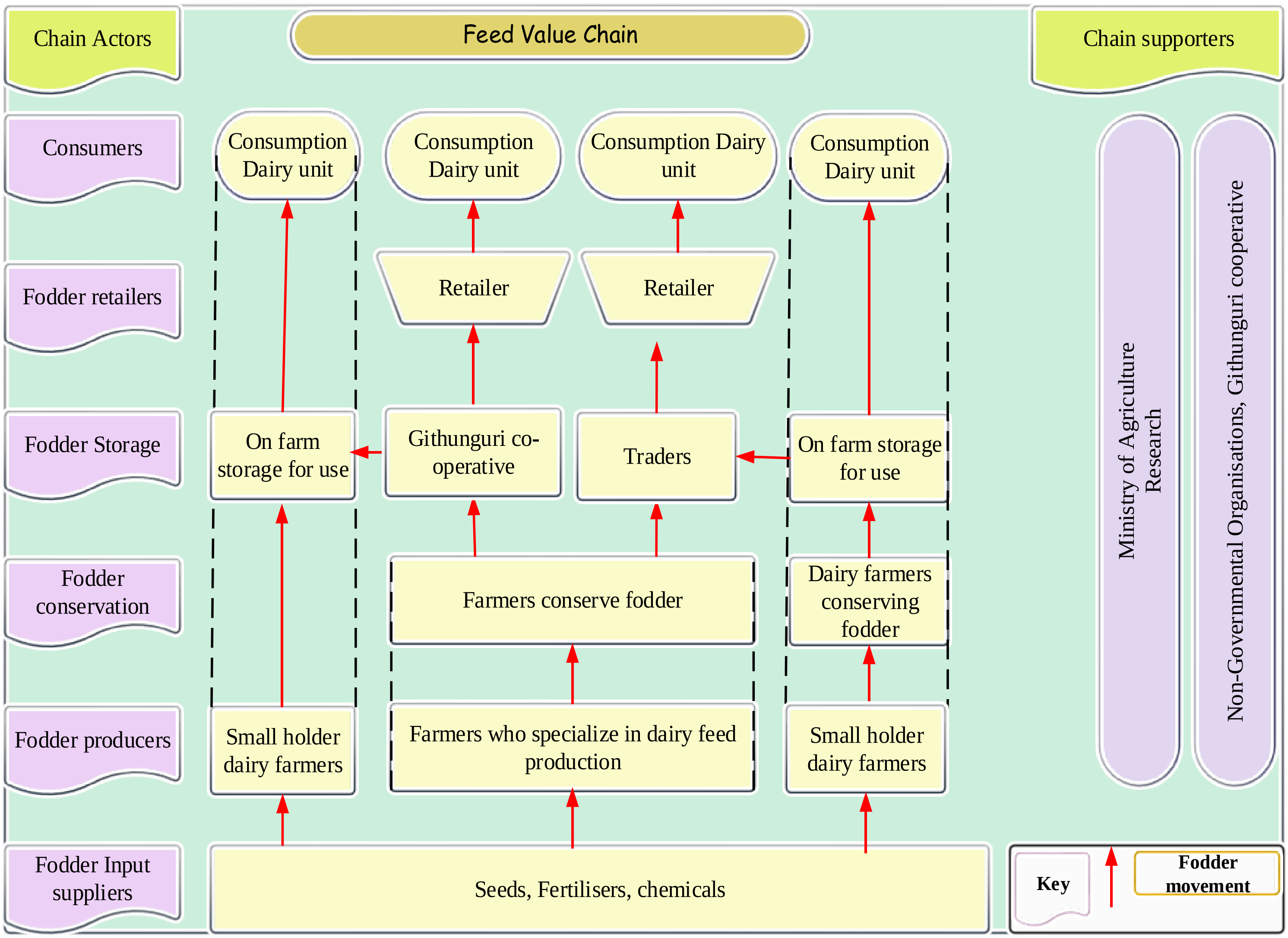
The smallholder dairy sector, however, is underperforming due to extreme weather events. Droughts and floods have led to reduced pasture and forage availability, degradation of the environment and an increase in destitution (World Bank, 2011). Droughts and extreme rainfall variability trigger periods of severe feed scarcity, especially in dry land areas, with devastating effects on livestock populations (Alock., 2011). Due to low soil fertility, farmers have resorted to increase feed production using fertilizers which also tend to increase greenhouse gas (GHG) emissions. This promotes climate change leading to more adverse effects than mitigatory measures, hence less quality feed for dairy animals. The alteration of quantity and quality of feed changes the species composition of grasslands consequently affecting the digestibility and nutritional quality of forage (Thornton et al., 2009). This also leads to increased greenhouse gas emissions. Thus, the need to focus on climate smart quality feed production. Insufficient poor-quality feed ultimately leads to low milk production which is inversely proportional to GHG emissions leading to increased climate change effects and reduced dairy feed production and productivity. Quality dairy feed availability and utilization have multifaceted implications in term of farm economics, environment, product quality, product safety, animal health. Therefore, a solution which increase feed production whilst reducing greenhouse gas emission is the cornerstone to dairy production efficiency, revenue and environmental sustainability.

2.2 Feed value chains governance

The feed value chain involves input suppliers which include Agrovets and general retail shops. These sell inputs to small holder dairy farmers who then produce their own feed. However, due to prevailing climatic conditions and small land sizes, their fodder needs to be supplemented hence they buy fodder from traders, retailers or GDFC. The cooperative also buys feed and sells it to the Cooperative members (small holder dairy farmers) at a subsidized price. This is a feed sustainability measure for the viability of the small holder dairy sector. Retailers also play a critical role in providing ease aces of fodder to farmers. Transporters operate at all levels.

2.2.1 Feed value chain

Figure 3: Feed value chain



Source (Author.,2018)

2.2.2 Support services

Awareness-raising and extension are important first steps towards the adoption of better technologies and practices. These require investments in communication activities, demonstration farms, farmer field schools, farmer networks and training programs. Sector organizations can play an important role in raising awareness among producers and disseminating best practices and mitigation success stories (Gerber et al., 2013). Supportive policies, adequate institutional frameworks and more proactive governance are needed to fulfil the sector's mitigation potential and promote its sustainable development. Extension and capacity-building policies can facilitate the transfer and use of more efficient practices/technologies that are readily available. Financial incentives are important complementary policy tools, particularly for mitigation strategies that increase risks and costs to farmers.

Good Governance: This Strategy will promote good governance that comprises Accountability (sound fiscal choices, made in a transparent manner, that give priority to productive social sectors such as agriculture); Transparency (decision-making, particularly in budget, regulatory and procurement processes that is critical to the effectiveness of resource use and the reduction of corruption and waste); The rule of law (a fair, predictable and stable legal framework to enable actors assess economic opportunities and act on them without fear of arbitrary interference and expropriation); and Participation (a consultation process that enables all stakeholders to participate in the formulation of development strategies and in the design and implementation of programs and projects). This principle will guide the Strategy in institutionalizing an overall enabling environment for implementation of CSA and mainstreaming climate change issues in agriculture.

The support services include researchers e.g. ILRI, CCAFS and Egerton University among others who are responsible for researches in Climate smart agriculture. Their researches are documented and published for information sharing and supporting informed implementation of developmental projects. The other support service comes from the Government extension services that is responsible for information sharing. They do this through use of pamphlets, focus group discussions, demo plots, look and learn tours and lead farmer methodologies. They have tried their best but it’s not good enough due to limitations in mobility and staff to cover wide areas. Thus, most farmers are still not aware of climate change and favor any means possible to improve production without taking an account of climate smart practices. Thus, a lot needs to be done in information sharing.

Of importance is research and development which is to improve the applicability and affordability of existing technologies. This ought to be supported by micro finance institutions schemes that support adoption of new technologies and practices. Within the framework of the National Climate Change Action Plan, the Government of Kenya is developing NAMAs in the agricultural sector to support climate-smart agriculture, i.e. low-emission, climate resilient and productivity-increasing agricultural investments (Van Dyke, 2015). Regulations relevant to climate smart are also critical as they include a well prescriptive approach such as mandating the use of specific mitigation technologies and practice.

The relationship of farmers and feed producers is not solid. They exchange product and money and rarely make lasting partnerships unless a credit scheme needs to be devised. In support of farmers is the Githunguri cooperative which facilitates the availability of fodder for farmers hence playing a critical role in the feed value chain. Due to production seasonality, farmers are dependent on fodder producers for the dry part of the year. Due to the supply and demand fluctuations, price of fodder is partially adjusted accordingly. Quality of fodder is another issue to be scrutinized as farmers just take what is on offer and this increases GHG emissions as the digestibility of low quality fodder is poor.

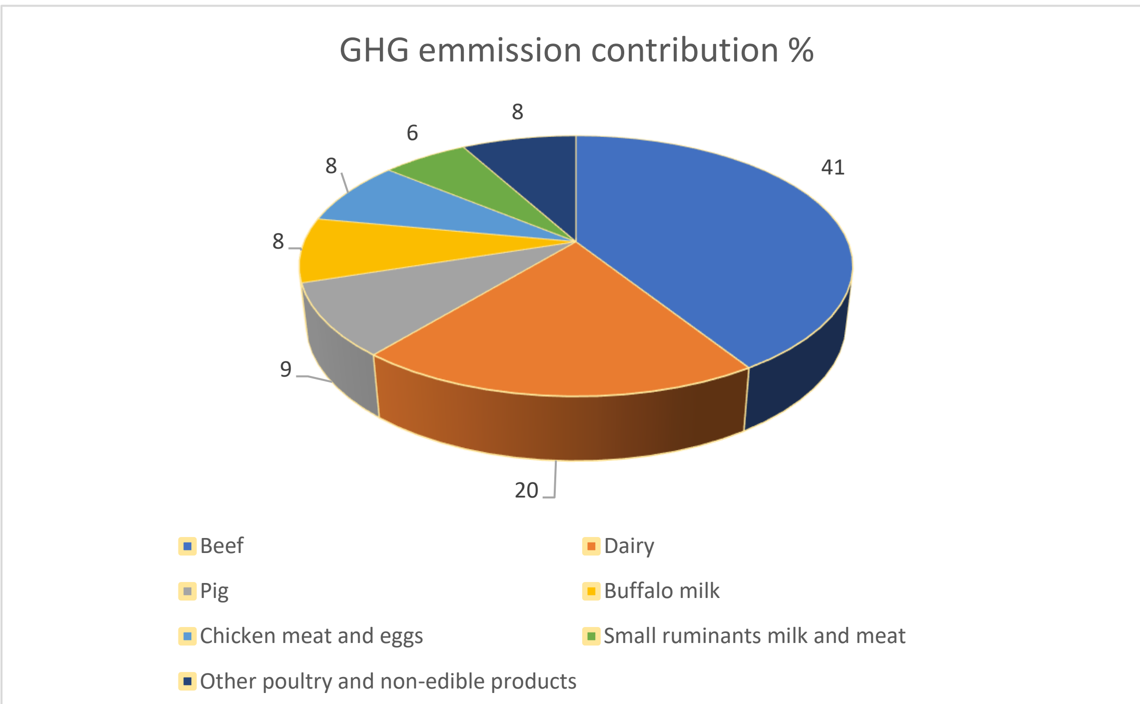
2.2.3 Costing

Feed constitutes a high percentage of costs in milk production, hence climate smart agriculture is critical in sustainably reducing feed costs. Most of the costs are incurred during production on farm and during the transactions along the chain. This consolidates the need for proper chain governance for farmers to aces affordable climate smart grown dairy feed. Hence, it is necessary during this study to do an analysis of feed production costs for informing policy and development of proper cost-effective farm business models. Improving plot feed inefficiencies will eventually improve feed efficiency along the feed chain through significant reduction in costs and increasing overall profit share for all stakeholders. This will be verified by the analysis of feed costs (Tegemeo, 2015). The costing will fulfil 3 major goals: Supporting farmers to improve farm management and economic performance, and supporting researchers and policy makers to identify interventions to improve on farm profitability (Staal et al, 2003). However, the absence of plot records is a major hindrance to obtaining accurate cost of milk production at plot level.

2.3 Contribution of livestock to Greenhouse gas emissions

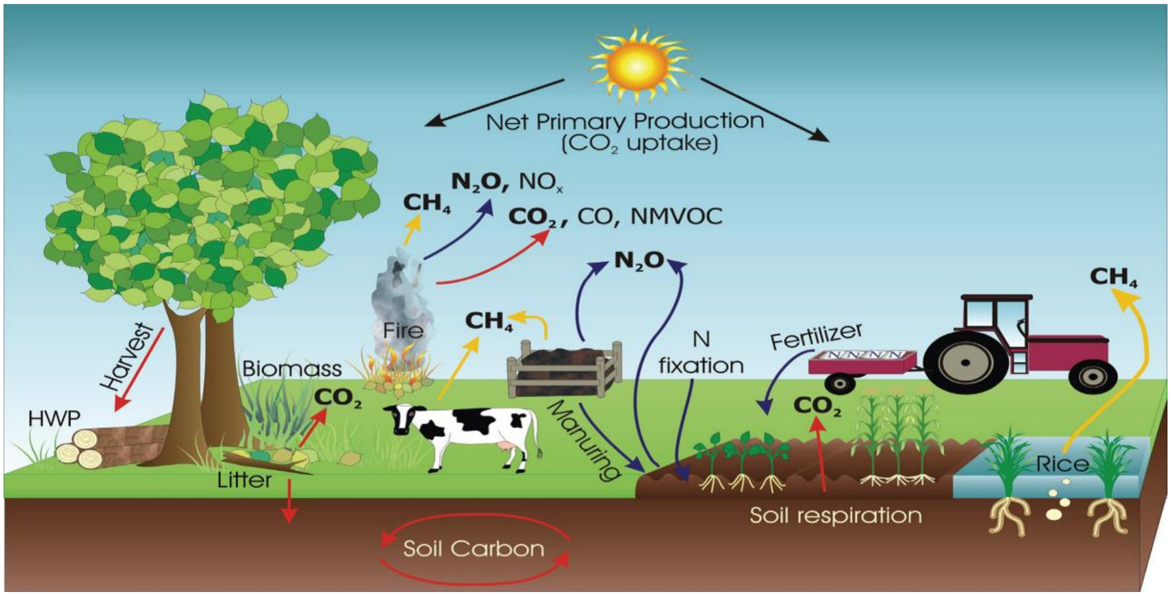
Livestock is responsible for 18% of greenhouse gas (GHG) emissions (9% CO_2, 37% methane and 65% N2O) (FAO, 2006). Ruminants (cattle, sheep and goats) account for a large share of the total livestock emissions, because they are less efficient in converting forage into useful products than monogastric (pigs and poultry) (Beauchemin and McGinn, 2005). Monogastric are not consuming forage (fodder), so cattle is more efficient. GHG emissions includes methane (CH4) emission from enteric fermentation and manure management, nitrous oxide (N2 O) emission from animal manure and carbon-di-oxide (CO2) emission from land-use change caused by demand for feed grains, grazing land and agricultural energy and as much as 37% of anthropogenic methane emission from the agriculture sector (FAO, 2006).

Figure 4: Livestock greenhouse gas emission contribution



Source (FAO, 2006)

Figure 5:Nutrient cycle in the dairy farm



Source: (Adopted from Dairynz, 2013)

2.3.1 Fertilizer application and greenhouse gas emission

In addition to droughts and floods, strong winds and dust storms also contribute to the reduction of forage availability as they erode top soil, thus making grass regeneration difficult even when it rains (World Bank, 2011). Poor soil fertility has led to the increased use of fertilizers for increased productivity. However, fertilisers have negative effects on GHG emission if used in excess thereby increasing the climate change effects and consequently reducing productivity. About 27% of emissions are related to the production of fertilizers, the use of machinery and transport for feed production. About 17 percent of emissions are caused by fertilization (emitting N2O) with both synthetic fertilizers and manure. Direct energy used on-farm contributes more to emission intensity in industrial systems of the region (6 percent) than the world average (4 percent) for industrial systems (Thornton et al. 2009). Hence there is need of adopting climate change mitigation strategies to increase production sustainably. Use of manure is essential in improving circularity and viability of the smallholder dairy sector at large.

2.3.2 Feed quality and greenhouse gas emission

Inadequate land size and unpredictable weather patterns have contributed to insufficient poor-quality feeds production. Poor feed quality has low feed digestibility leading to high enteric CH4 emissions and low animal production performance. Thus, promoting negative effects of climate change. Improving the digestibility of the diet, through climate smart feed production, feed conservation or addition of locally available improved forages, results in better lactation performance (i.e. higher milk yields and animal growth) and reduced CH4 emissions (Gerber *et al.*, 2013). Feed production and processing, and enteric fermentation from ruminants are the two main sources of emissions, representing 45 and 39 percent of sector emissions, respectively. CO2 emissions are also related to fossil fuel consumption during processing and land use activities. Diet improvement through improved digestibility has the highest mitigation potential, owing to its large impact on several sources of emissions. Hence, climate smart agriculture/feed production is of utmost importance for provision of quality feed to dairy cattle.

2.3.3 Milk production and greenhouse gas emissions

Low production of poor-quality feed decreases milk production and has perennial consequences reflected in increased GHG emissions. In dairy production, there is a strong relationship between productivity and emission intensity – up to a relatively high level of productivity, emission intensity decreases as yield increases (Gerber *et al.*, 2013). Better animal feeding and nutrition reduce CH_4 and manure emissions (lower release of N and volatile solids). Higher milk yields imply a shift of the cow's metabolism in favour of milk and reproduction as opposed to body maintenance, contributing to lower emission intensities. High-yielding animals producing more milk per lactation generally exhibit lower emission intensities for three main reasons. First, because emissions are spread over more units of milk, thus diluting emissions relative to the maintenance requirements of the animals. Second, because productivity gains are often achieved through improved practices and technologies which also contribute to emissions reduction, such as high-quality feed and high-performance animal genetics. And third, because productivity gains are generally achieved through herd management, animal health and husbandry practices that increase the proportion of resources utilized for productive purposes rather than simply being used to maintain the animals (Gerber *et al.*, 2013). This results in a reduced standing biomass (both in lactating and in replacement herds) per unit of milk produced. The impact per unit of milk is therefore reduced at both the individual cow and dairy herd level. Hence all these are a function of feed productivity and quality. So, it's imperative to concentrate this research on sustainable increase in quality and quantity of feed through adoption of climate smart agriculture practices.

2.3.4 Manure cycling and greenhouse gas emission

Inefficient digestibility of poor quality feeds results in an increase in livestock waste. Improving digestibility efficiency by improving feed quality and quantity production and animal productivity can result in less livestock waste and lower emissions for the same production level. However, manure plays a very critical role in replacing synthetic fertilisers hence improving circularity and sustainability of dairy feed production. The value of livestock waste as fertilizer is currently underutilized in Kenya (Ministry of Agriculture 2010). Better residue management and utilization of livestock waste can improve nutrient availability for the production of feeds, grasslands and crops and also reduce nutrient overloads and pollution in other areas. In addition to that, there is promotion of usage of bio-gas to reduce methane emission in Kenya. This is a highly efficient intervention in terms of greenhouse gas mitigation.

2.4 Climate smart agriculture mitigation measures

FAO estimates that by applying practices with the lowest emission intensity, emissions could be reduced by 18-30% without reducing overall output (Gerber et al. 2013). This will have cascading effects to the climate change challenges rampaging feed production and productivity. Most mitigation interventions can provide social, environmental and economic benefits.

2.4.1 Land use

Reducing land-use changes can contribute to mitigation. Emissions from pasture area expansion results in an estimated 9 percent of the sector's emissions. Hence, dairy herd efficiency improvements were estimated to reduce grazing land use and associated land-use change emissions by up to 25 percent. Soil organic matter, the primary form of carbon in soils, serves several functions; from an agricultural standpoint, it is important as a "revolving nutrient fund", as well as an agent to improve soil structure, maintain tilth and minimize erosion (FAO, 2005). When soil organic matter is lost, either through inadequate agricultural practices in feed production or pasture degradation, the productivity of land decreases over time. Thus, managing land use is critical as a mitigatory measure.

2.4.2 Pasture reinforcement

Pasture reinforcement involves sowing of legumes in some grassland areas to reinforce the pastures and improve their quality. Intensification of smallholder dairy production improves carbon sequestration through reduced animal movement in pastures, farmers practice ‘cut and carry’ method. The impact of better grazing management can have a positive impact on forage production and soil carbon sequestration. Other practices which are used to further increase grassland soil carbon stocks include; sowing of improved, deep-rooted tropical grass species and improved fire management (Gerber *et al*. 2013). Also, forage quality can be improved by increasing feed digestibility through the processing of locally-available crop residues (e.g. treatment of straw with urea) and by the supplementation of diets with better quality green fodder such as multipurpose leguminous fodder trees, where available. Better feed digestibility leads to better animal and herd performance. Pasture reinforcement can be improved by adding manure. Reinforced pastures feed production can reduce greenhouse gas emission and improve circularity by recycling nutrients and energy contained in manure. Thus, contributing immensely to mitigation.

Grevillea robusta (Silk-oak grevillea, Encino plateado) is one of the common trees in Kenya used for animal feed and intercropping. It is a nitrogen-fixing, very versatile grows rapidly. Traditionally it has been used to shade coffee trees, but it is currently used as fuelwood, lumber, posts and its leaves are used to make fertilizer. The branches like the roots are very hearty and grow in soils with few natural nutrients. It has higher tolerance to heat, stress, pests and diseases. (http://www.newforestsproject.org/species.html)

2.4.3 Agriculture practices

The main climate smart agriculture practices include improved fodder production (Napier grass, Rhodes grass, Brachiaria grass, Columbus grass, forage sorghums, Desmodium, Dolichos lab and Lucerne (Alfalfa); agroforestry and fodder trees (Calliandra, Leucaena, Trichandra, tree Lucerne, Sesbania sesban, Grevillia and Croton); tree nursery establishment and management for both fodder shrubs and agroforestry trees; better manure management through composting and biogas generation and feed conservation by baling hay and making silage (Rosenstock et al., 2014). These practices improve carbon sequestration; reduce greenhouse gas emission; increase dairy productivity and efficiency of resource use; conserve natural resources; address livestock waste which will be used for fodder production; and promote development and consumption of climate smart feeds (Rosenstock et al., 2014).

2.4.4 Dairy production climate smart practices

Adoption of technologies and practices that improve production efficiency at dairy herd level significantly reduce greenhouse gas emissions. Practices and technologies that reduce emissions can often simultaneously increase productivity, thereby contributing to food security and economic development. These include the use of feed additives or improved feeding practices can achieve lower emission intensities by improving feed efficiency (higher feed conversion ratios) and animal productivity. Enteric and manure emissions are reduced while productivity is increased at animal and herd levels (Gerber et al. 2013). Sourcing low emission intensity inputs (feed and energy in particular) is a further option. However, concentrates are expensive and are not economically feasible for small holder dairy producers.

In addition, on-site energy consumption is generally marginal in production cost structure but can be high in some cases, for example in intensive milk production systems. Energy-use efficiency can be improved by the adoption of better management practices (e.g. maintenance of equipment and operating time) and energy saving devices (e.g. heat pumps and thermal isolation), reducing both emissions and energy costs for farms and processing plants (Beauchemin, 2005).

There are two ways of conservation which are:

Figure 6: Hay

Hay - It is a method were moisture content is reduced through air or sun drying as shown on fig 6. This slows the growth of microorganisms that causes spoilage of the conserved forage. Moisture content is reduced from 80% to 15%. Forage used for hay should attained 50% flowering for this to have a maximum digestibility. It should be harvested 2 to 3 days before drying. A mixture of grass and legumes will make a better quality of hay.

Figure 7:Silage

Silage –

Compared to hay, silage is a high-moisture forage preserved through anaerobic fermentation as shown on fig 7. Forage crops utilised for silage should have adequate level of water soluble carbohydrates and with dry matter of 20%. Basically, it is done by chopping the forage crops, some mixed it with molasses and pressed not allowing to have presence of air that will stimulates the growth of microorganisms. Covered with plastic sheets and thin layer of soil depending on the type of silo. Fermentation is complete after 21 days.

2.4.5 Antibiotic use

Antibiotics are anti-bacterial drugs used for treatment of mastitis, dry cow therapy and other bacterial infections or to prevent secondary infections when immunity is compromised. However, they are not to be abused to avoid antibiotic resistance. Abuse of these drugs retards achieving climate smartness since misuse resemble mismanagement hence contributing to proliferation of bacteria, stunted growth, poor digestibility, reduced milk yield and consequently excessive greenhouse gas emissions.

2.5 Sustainability

Access to quality fodder and feed remains an issue retarding the growth of a sustainable and competitive dairy sector in Kenya. So, the feed value chain needs to be resilient, robust and reliable for it to be economically sustainable for farmers to continue in the business. This involves economic, environmental and social sustainability. The sustainability of a feed chain is a function of all the value chain actors. It involves formalizing the chain for quality feed assurance to farmers and compliance to safety and regulatory frameworks. This will ensure availability of quality feeds for farmers. In addition to that, greenhouse gas free production of quality feed ensures viably sustainable availability of feed. In case of an extra demand for feed on a farm, there is need of reducing value share of low quality feed and consider efficient costing of feed (Bebe et al., 2016). Hence, the opportunities that characterize the sustainability of the feed chain and institutional governance help us to understand the robustness, reliability and resilience of the feed value chain. This involves implementation of climate smart agricultural interventions related to fodder production, conservation, storage and consumption.

2.5.1 Robustness of the feed value chain

This is the consolidation of feed value chain actor's relations. This is done to reduce feed transactional costs and enhance efficient transactions and product quality and safety hence reducing unnecessary risks. There are farmers specializing in feed production and some are contracted by the Githunguri cooperative to produce feed for farmers, thus there is need of a sustainable cost-effective supply of feed for dairy viability. Some farmers also produce but value addition and conservation is neglected, so its necessary that climate smart sustainability measures be implemented foe a robust value chain to be efficient (Kilelu et al., 2016).

2.5.2 Reliability - institutional governance

Institutional governance is public-private cooperation i.e interaction of stakeholders in the feed value chain. The role of the Government is critical in coordinating various stakeholders, support private investments with favorable polices and facilitate trade opportunities. Propper implementation of a sound framework increases reliability of the feed value chain hence climate smart practices can be incorporated with ease by every farmer involved (Bebe et al., 2016). Use of a dairy feed hub may also be considered for development of a robust and reliable feed chain as this has the potential to reduce transactional costs which are hampering small holder dairy viability. These innovation platforms will also discuss economic incentives, levies and taxes which are opportunities for building a reliable climate smart feed value chain.

2.5.3 Resilient - innovation support systems

Addressing the challenges and exploiting the growing opportunities in the Kenyan dairy sector hinges on actors continually exchanging knowledge, mobilizing resources and coordinating co-innovation networks that support development of capacities like entrepreneurship for social-technical, institutional innovation (Kilelu et al. 2016). Research plays a critical role; therefore, researchers should focus on climate smart agriculture efficient innovations and strengthen their connections with small holder dairy farmers. Farmers are to take dairy farming as a business and apply suitable and efficient climate smart agriculture methodologies. In addition to that, they are to seek knowledge by networking with various stakeholders involved in the chain. Also, graduates in the field of agriculture need to be competent and provide quality and efficient services to farmers. All this will produce a robust, reliable and resilient feed value chain for small holder dairy farming (Bebe et al., 2016).

2.6 Instruments for climate smartness evaluation

For a systematic assessment of the feed value chain in relation to climate change, the following instruments and models were used to come up with conclusive climate smart agronomic practices and best way top integrate them in the current farming systems.

2.6.1 Resource evaluation matrix

This instrument gives an evaluation of farmer's views regarding the dairy unit, feed production critical aspects and other natural resources that influence climate smart agriculture. Farmer's opinion, together with visual appraisal of the plot and all related parameters will then be documented and analysed.

Plot visit will be carried out and the resource evaluation matrix will be used to evaluate the plot and have an in-depth understanding of the farming systems in Kenya. Table 1 shows the resource evaluation matrix.

Table 1:Resource evaluation matrix

Dairy Resource		**Is there enough for the dairy unit?**	**Quality**
Portable water			
Rivers			
Fodder	Grasses		
	Fodder trees		
	Legumes		
Agroforestry	Trees		
Soil			
Biogas	Floating drum		
	Fixed dome shaped		
Dairy cattle	Holstein Frisian		
	Aryshire		
Dairy Equipment	Chaff cutter		
	Milking machine		
Other livestock species	Goats		
	Chicken		
Farm structures			
Farm workers			

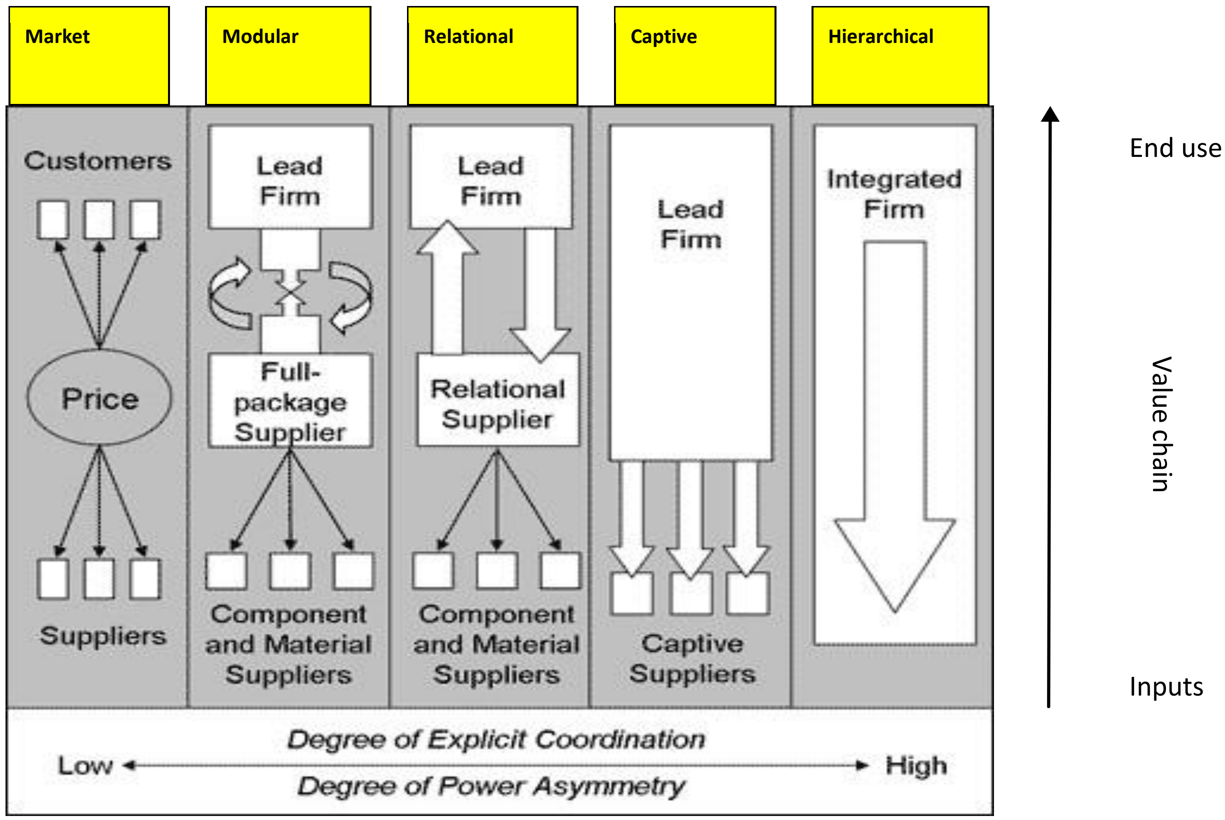
Adapted from 80 tools for participatory development (Geilfus., 2008)

2.6.2 Feed value chain governance

Climate smartness starts with the relationships among actors in a value chains since they influence all other activities including rules, regulations and standards to be met. Therefore, value chain governance also reflects the requirements by legislation, regulations and rules, apart from the competitiveness and expectations of markets. In addition, it shows the relationship with service providers that operate within or influence the range of activities required to bring a product or service from inception to its end use. The key parameters include- The product design and specifications of what is to be produced, how it is to be produced (production processes, and environmental standards) and production scheduling and logistics of quantities to be produced (Gereffi et.al. 2003). The five types of governance include Market, modular, relational, captive and hierarchical. These are shown in fig 8.

Governance of feed chain – The instruments of governance include among others: contracts between value chain actors, standards for products and processes, self-regulatory systems in value chains, management of producer organizations, government regulatory frameworks, unwritten norms that determine who can participate in a market as well as expectations from the public.

Figure 8:Typology of governance systems in value chains



Source: (Gereffi et.al. 2003)

2.6.3 Seasonality of the study area

For a comprehensive conclusion and crafting of sound recommendation for integration of climate smart agriculture, the season analyses is important. The outline of the rainy and dry season can be given by farmers in a focus group discussion. This will reveal periods of wet pentads dry spells which influence fodder demand versus quality availability. The calendar is the most important instrument of data collection. The farmers can also advise on strategies they implement in dry periods and how they perceive different types of hay available on the market.

2.6.4 Costing of fodder production

The cost of production will be calculated to determine the profitability of growing fodder on the small pieces of land. This will then reveal the relevance of longevity of the dairy unit since feed consumes 65% of the total dairy unit costs. The following formulas will be used to calculate the cost and profitability of on plot fodder production.

GO = Qi * Yi* Pi

GO – Gross output, Qi – Quantity harvested, Yi – Number of harvests/ year, Pi – Selling price/ unit harvested

GM = GO – (Vi + Fi)
GM – Gross Margin, GO – Gross output, Vi – Variable costs, Fi – Fixed costs

Net Income = GM – (Depreciation + Interest)

2.6.5 Institutional Analysis

In order to satisfactorily ensure proper integration of climate smart agriculture practices in Githunguri small holder dairy farming systems and improve on feed value chain climate smartness, there is need to analyse the capabilities of the organizations and their external environment with emphasis on the actors.

2.6.5.1 Stakeholder Analysis

Figure 9: Power and influence grid

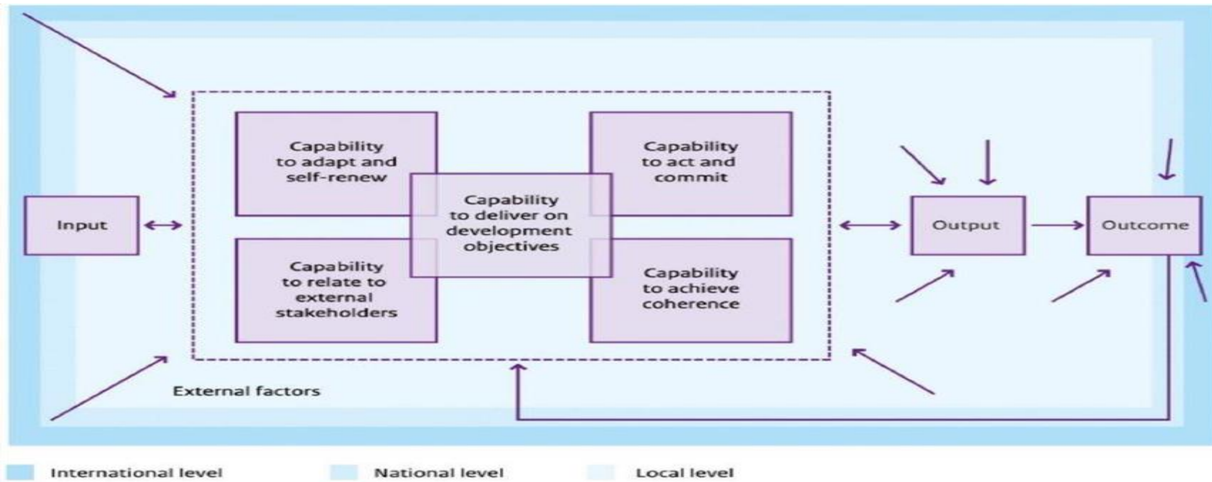
The stakeholder analysis will be conducted in a focus group discussion to identify key players and proper positioning of other stakeholders. The diagram by eden and Ackerman, fig 9, will be used to categorise and give a clear reflection on how to consider different stakeholders.

Power and influence grid (Eden and Ackerman, 1998)

2.6.5.2 The 5 Cs

This is a model that helps evaluate an organization and its ability to achieve something in a wider environment. This has been defined as: "Capacity is the overall ability of an organization or system to create value for others." (Keijzer et alii 2011:13). The 5 capabilities include capability to adapt and self-renew, capability to act and commit, capability to relate to external stakeholders, capability to achieve coherence and finally capability to deliver on developmental objectives. The 5 Cs model s shown in figure 10.

Figure 10: The 5Cs model

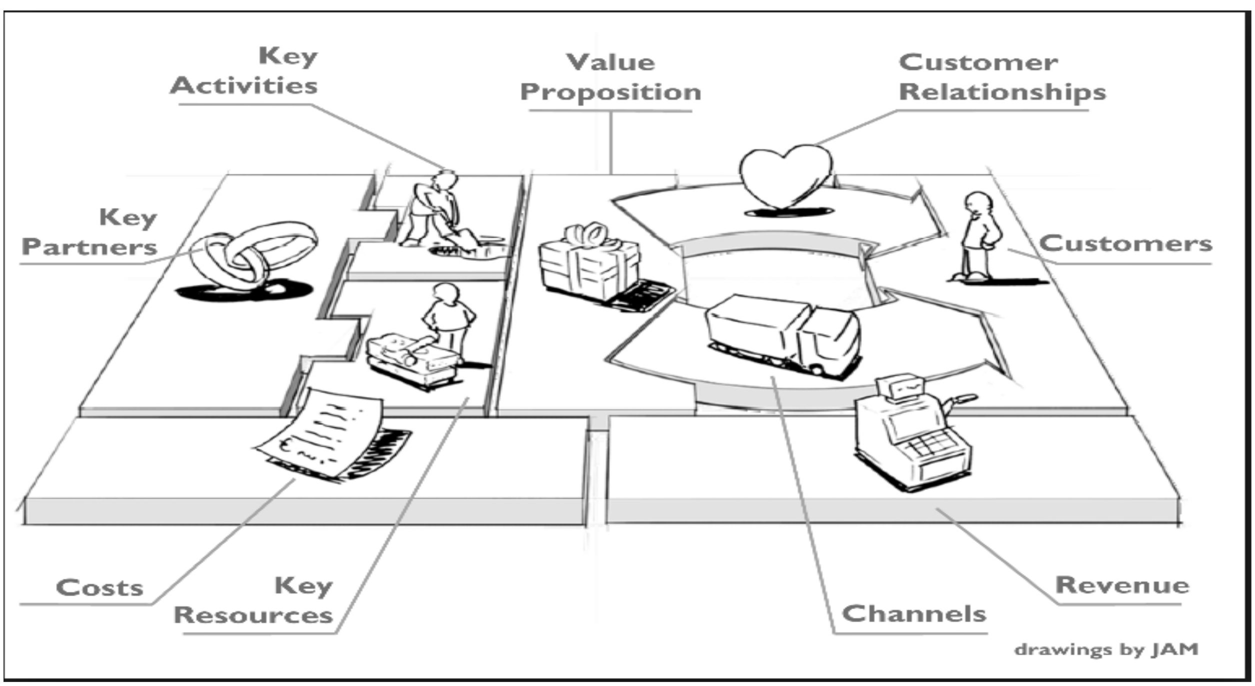


Adapted from De Lange., 2009

2.6.6 Canvas Business Model

The business model canvas is a simple tool for designing innovative business model. It is a strategic management and entrepreneurial tool that allows to describe, design, challenge and invent and pivot a business such as dairy fodder production involving smallholder dairy farmers in Githunguri Sub-county. The business model canvas is a hands-on tool that fosters understanding, discussion, creativity and analysis of a business. It is a faster and more effective way to communicate with internal and external stakeholders of a business such as dairy fodder production in Githunguri Sub-county. The various components are indicated in fig 11.

Figure 11: Business model canvas elements in detail



(Source: Osterwalder et al., *2010)*

Table 2: Business model canvas

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Proposition</th><th>Customer Relations</th><th>Customer segments</th></tr>
<tr><td rowspan="3">Who are key partners?
Who are our key suppliers?
Which key resources are we acquiring from our partners?
Which key activities do partners perform?</td><td>What key activities do our value propositions require?
Our distribution channels?
Customer relationships?
Revenue streams?</td><td rowspan="3">What value do we deliver to customers?
Which one of our customers problems are we helping to solve?
What bundles of products and services are we offering to each segment?
Which customer needs are we satisfying?
What is the minimum viable product?</td><td>How do we get, keep and grow customers?
Which customer relationships have we established?
How are they integrated with the rest of our business model?
How costly are they?</td><td rowspan="3">For whom are we creating value?
Who are our most important customers?
What are the customer archetypes?</td></tr>
<tr><th>Key Resources</th><th>Channels</th></tr>
<tr><td>What key resources do our value propositions require?
Our Distribution channels?
Customer relationships?
Revenue streams?</td><td>Through which channels do our customer segments want to be reached?
How do other companies reach them now?
Which ones work best?
Which ones are most cost efficient?
How are we integrating them with customer routines</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="2">Cost Structure</th><th colspan="3">Revenue streams</th></tr>
<tr><td colspan="2">What are the most important costs inherent to our business model?
Which key resources are most expensive?
Which key activities are most expensive?</td><td colspan="3">For what value are our customers really willing to pay?
For what do they currently pay?
What is the revenue model?
What are the pricing tactics?</td></tr>
</table>

The business model canvas was done together with the GDFC management.
Cost structure: This describes the monetary implications while operating under various business models. It identifies whether a business is concerned in reducing cost i.e. cost driven or is less concerned with cost and focusing on value creation for its products such as feed. Characteristics of cost structure involves fixed costs, variable costs which change according to production levels within the business. Costs within the business go down as the amount of goods are ordered or produced, i.e. economies of scale.

Revenue streams: Relates to the way a company makes money from each customer segment in different ways through asset sales, advertising, licensing i.e. revenue model. The pricing tactics and how are they paying or willing to pay.

Key activities: This entails the most important activities within a business to attain the value proposition. This can include activities in the production part of the business such trainings, feed production and biogas installations

Value proposition: The collection of services a business entity offers to meet the needs of its customers which distinguishes it from its competitors. It provides value through elements such as its new performance, accessibility, design, brand, price, cost reduction, usability and accessibility.

Key partners: Key partners are important to optimize operations and reduce risks in the ever-changing market or business environment. Strategic partners with suppliers which can be cultivated through joint ventures, strategic business alliances with also service providers to the business.

Key resources: Key resources are important for any business to create value to its customers. They are considered the assets which are needed to sustain and support the business which could be human, physical or financial resources.

Customer segments: To build an effective business model a company must try to identify its customers segmented based on the different needs, attributes, market response to ensure appropriated implementation of co-operate strategy meets the characteristics of the selected group. Customers segments include, niche market and mass market.

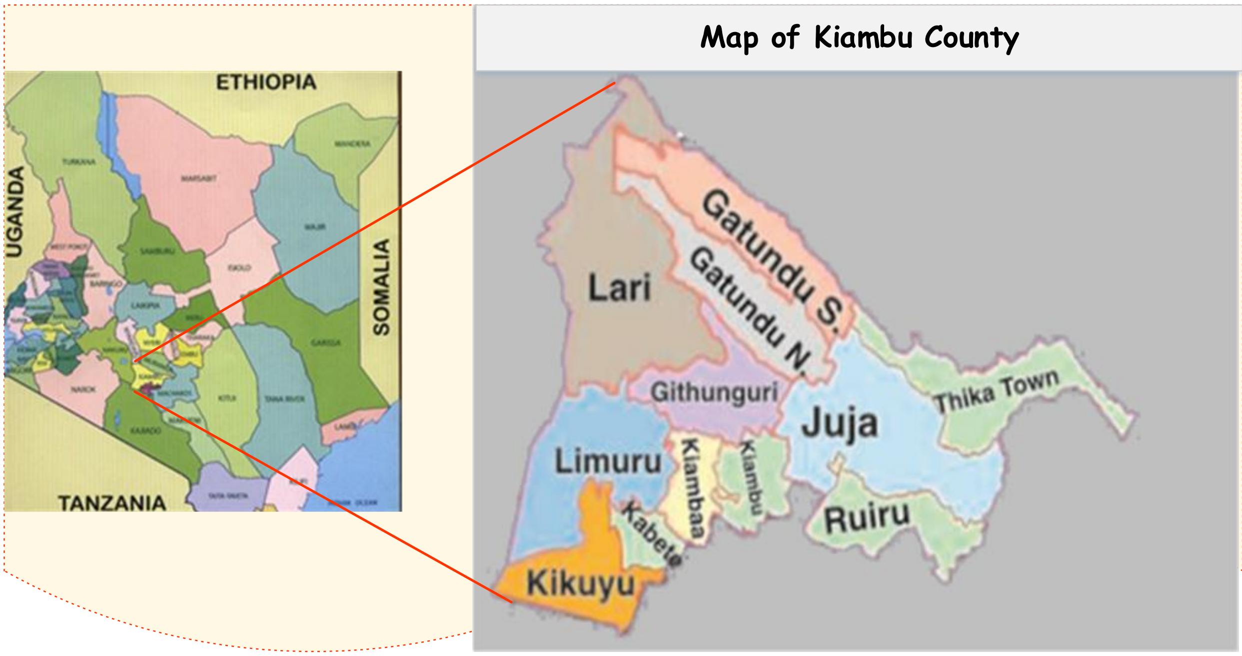
2.6.7 Linkages to finance

Farmer linkages to finance are critical for sustainability of dairy projects as well as implementation of the climate smart practices. Another business model that show linkages of institutions will be designed. This includes money flow, milk product flow, services rendered by partnering stakeholders and information through awareness campaigns.

Chapter 3: Methodology

3.1 Study area

Figure 12:Kiyambu County



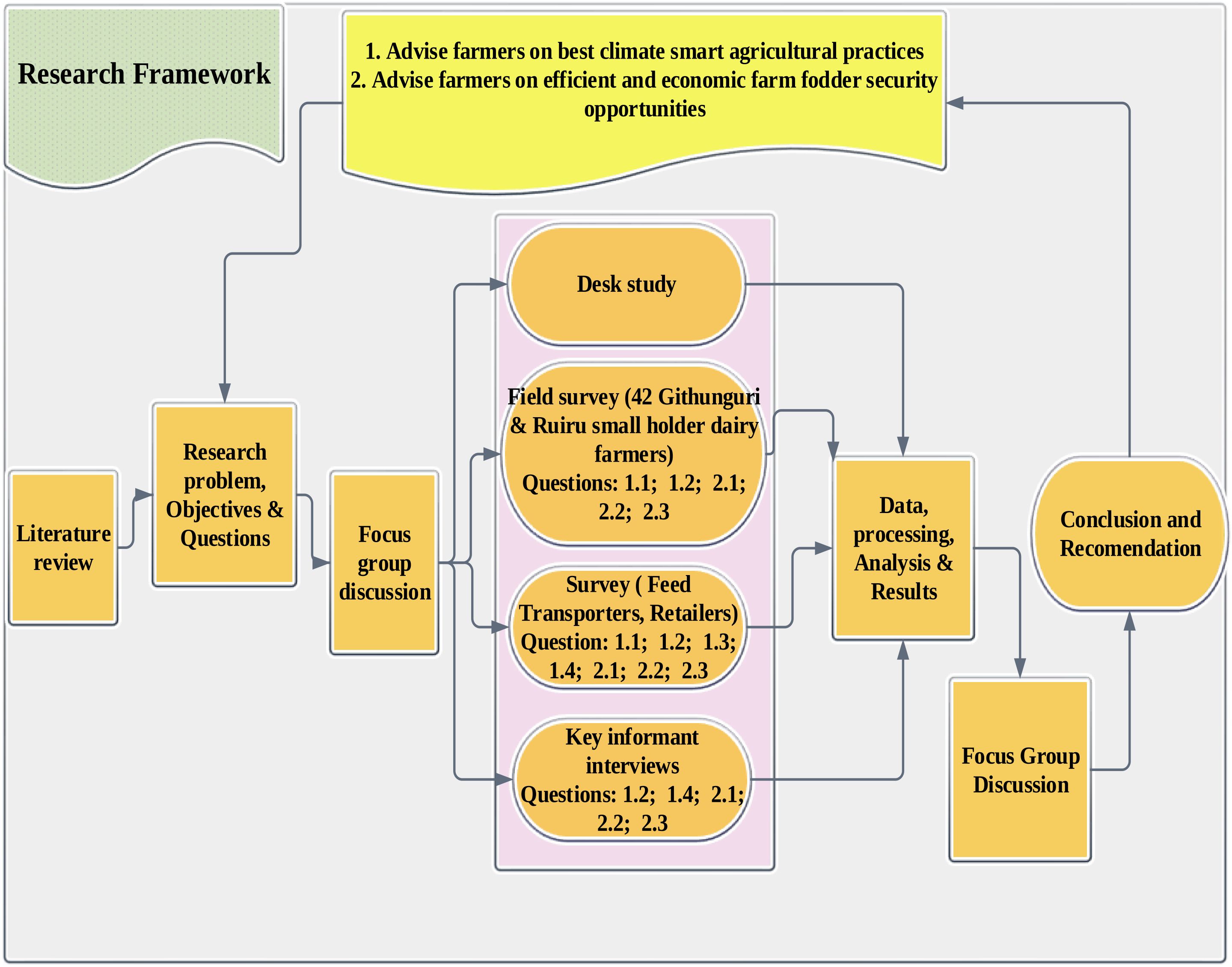
The study will be conducted in Githunguri and Ruiru sub-counties of Kiambu county. Kiambu County is in central Kenya, as shown on figure 12; it borders Murang'a County to the North and North East, Machakos County to the East, Nairobi and Kajiado counties to the South, Nakuru County to the West, and Nyandarua County to the North West. The county has a warm climate with temperature ranging between 12^{0}C and 18.7^{0}C. It has population of ,621,436 (Male – 49%, Female – 51%) and a total area of 2,543.4 Km^2. The rainfall aggregate for the county is 1000mm each year. The cool climate is conducive for farming. The county relies on Agriculture for its economy. Majority of the residents are small scale farmers. Githunguri and Ruiru sub counties are some of the 12 Kiambu sub-counties. Githunguri sub-county is wholly serviced by GDFC society whilst Ruiru is partially serviced as only farmers registered with the GDFC society are beneficiaries of services. GDFC society has a 230,000 liter processing plant with 24,936 affiliated members.

3.2 Research design

A research was conducted in Githunguri and Ruiru Sub-counties of the Kiambu county. It had both qualitative and quantitative design. A random sampling of Githunguri Small Holder dairy farmers and snow ball sampling of Ruiru farmers was conducted.

This research was done as part of a research team. Focus group discussions were conducted at the onset and at the end of the survey. A total of 42 farmers were interviewed from Githunguri. In addition, a total of 10 feed transporters were also interviewed. Finally, key informants were also valuable source of information during data collection. The research framework is shown on figure 13.

Figure 13: Research framework



Source (Author., 2018)

Sampling plan and procedure

Probability and non-probability sampling of Githunguri Small Holder dairy farmers and feed value chain actors will be done. In the population of Kiambu county, a sampling frame of Githunguri sub-county small holder dairy farmers will be considered with a sample size of 40 small holder farmers, 10 feed suppliers and at least 10 key informants. Key informants will be valuable source of information during data collection and their number will be increased since this research is part of a research team meeting different stakeholders. Feed suppliers sourcing feed from outside the constituency will also be interviewed.

1.1.1 Research approach, method, tools

The research approach, method and tools are shown on table 3.

Table 3: Research approach

Research approach	Method	Tool for data collection		Questions
• Value chain approach	• Focus group Discussion	• Mapping • Ranking • Farming calendar	• SNV • Farmers • Egerton University student • Githunguri dairy cooperative • Government extension staff	• 1.1; 1.2; 1.4, 2.3, 2.4
	• Survey	• Questionnaire	• Farmers • Githunguri extension workers	• 1.1; 1.2; 1.3; 1.4; 2.1; 2.3; 2.4
	• Case study	• Semi-structured interview checklist • Observation	• Fodder transporters • Farmers • Government and private extension workers	• 1.1, 1.2; 1.4; 2.1; 2.2; 2.3

Source (Author., 2018)

1.1.2 Desk research

Literature review will be carried out to gain in-depth information about; dairy feed value chain, farming system, socio-political drivers and trends in dairy feed production sector, economic drivers and trends in dairy feed production. The information gathered will help in laying the foundation for research and understanding factors that hamper scaling up of climate smart agriculture interventions. Relevant information will be gathered from books, journals, reports and other relevant documents.

Observation method will be used to answer research sub- question on the type of farming systems that are used in Githunguri Sub-county

1.1.3 Data collection

The survey was conducted in the month of July and August 2018. The respondents were randomly selected using probability and non-probability sampling from among the smallholder farmers (SHF) into dairy production farming. House-hold heads (HH) or their spouses were interviewed. In case of single male or female headed households, the head or any other person in the family assisting the head in decision making was interviewed. 20 key informants were also be interviewed using the check list questions from the same questionnaire to provide check list information on Climate smart feed production practices. The key informants included Divisional Extension Coordinator (DEC) and frontline Extension Staff (ES), GDFCS management, GDFCS extension workers. Structured pre-tested questionnaire with closed and open-ended questions were used to collect empirical qualitative and quantitative data about the social, technical and economic characteristics of the dairy feed farming system. The focus of the study will mainly was on the adoption of climate smart agricultural practices which could increase feed production on smallholder dairy farms within the division and thus contribute to increased farm income and resilience in feed supply sustainability.

3 FGD were used together with other visual tools to understand the dairy value chain and climate smart practices. In addition to that, costing was done to have the feed cost structure for quantitative analysis.

1. Data analysis and processing

Table 4:Data analysis and processing

	Research Question	Method / tool of data collection	Method of data analysis	Expected outcome
1	**What are the key characteristics in small holder dairy feed value chain?**			
i	What are the characteristics of Githunguri small holder dairy farmers?	Observation, mapping, transect, questionnaire, FGD	Resource evaluation matrix Descriptive statistics, Leven's test	livelihood style Characteristics of SHDF
ii	What are the governance characteristics of feed value chain?	Questionnaire, Semi-structured interview checklist, FGD	Descriptive statistics	Feed value chain analysis Feed value chain governance analysis
iii	What is the cost price and profitability of fodder production?	Questionnaire, Semi-structured interview checklist	Gross margin budget	SHDF production economics
iv	What role is support services partaking in climate smart agriculture information sharing?	Questionnaire, Semi-structured interview checklist, FGD	Descriptive statistics	support services in CSA Power relations of actors
2	**What are the opportunities to upscale dairy feed production whilst decreasing green house gas emmissions?**			
i	What are the climate smart dairy farming practices implemented on the farms?	Questionnaire, Semi-structured interview checklist, Desk research, Observation	Descriptive statistics	CSA practices in dairy feed production
ii	What is the seasonality of farm feed production?	Questionnaire, Farming calendar, Mapping, Observation, Ranking	Descriptive statistics	Seasonality in feed production
iii	What are the potential efficient business models for climate smart fodder production?	Focus group discussion	Canvas business model	CSA business model
iv	What is the potential of introducing new and more efficient climate smart dairy farming practices in small holder dairy feed production?	FGD, Semi-structured questions, Observation	Power and influence grid, welfare tri-angle, 5 Cs,	Capacity and capability of GDFCS to integrate CSA practices

Source (Author., 2018)

SPSS V25 program was used for descriptive statistical analysis and analysis of variance (ANOVA) to test for the homogeneity in the different farm categories. The literature review was done to validate the results on Climate Smart feed production practices on smallholder dairy farmers. The literature search included latest publications, books, internet sites. Data analysis and processing is shown on table 4.

Study limitation

- Some information may have been lost due to translations.
- There were some inevitable changes to my topic due to different conditions that I found on the ground.
- Feed producers were not interviewed because they are in other counties away from Githunguri. However, information from them was collected via transporters who were knowledgeable about their production of Boma rhodes

Chapter 4: Scalable dairy and agronomic climate smart practises

In this chapter, data collected from field survey, key informant interviews, focus group discussions and case studies is presented. Several methods and tools such as charts, tables and themes are used in the analysis.

2.7 Farming systems

In both Githunguri and Ruiru sub-counties, dairy production is the most important enterprise, in comparison to other projects on the plot, because it brings cash on either daily or monthly basis depending with the marketing channel. Milk payments for the farmers supplying GDFC is monthly whereas those selling locally, especially Ruiru sub-county, get cash on a daily basis. Most farmers grow Napier for their dairy animals. On their small plot they also grow maize for home consumption and use the stover to feed dairy animals without any value addition to the stalks. Thus, maize is also used as a source of income in addition to household consumption (especially in Ruiru). The dairy units are under intensive system together with goats, for those rearing small stock. In poultry production, broilers are more common than indigenous hen though very few farmers are into poultry production. Samples of pictures of livelihood source are shown in fig 14. In addition to that, intensive pig production is another source of livelihood. The plot sizes inhibit variety of fodder to be grown on those small sizes of land. All farmers supplying their milk to GDFC are paid via SACO (financial institution) hence aces to loans is possible and credits for dairy unit improvement or household cash supplementary budget is available.

Figure 14:source of livelihood

Intensive dairy production	Intensive goat production	Napier grass chopping by chaff cutter

A plot with milk production above average was selected to conduct an evaluation. A transect was done and a resource evaluation matrix used to evaluate the current resources available on plot in relation to on plot feed production. The following results in table 5 were noted:

Table 5:Resource evaluation matrix

Dairy Resource		**Is there enough for the dairy unit?**	**Quality**
Portable water		Yes	Its borehole water pumped and stored in a tank for future use
River		Yes	It is an annual water source
Fodder	Grasses	Yes	They use cut and carry system hence feed is fed fresh
	Fodder trees	No	They are leguminous hence fix nitrogen into the soil
	Legumes	No	
Agroforestry	Trees	Yes	Eucalyptus carbon sink was established 3 years ago
Soil		No	The land size is small for growth of enough feed
Biogas	Floating drum	Yes	Its strategically positioned and powers both the dairy unit and homestead
	Fixed dome shaped	No	
Dairy cattle	Holstein Frisian	Yes	Averages 20 litres per animal
	Aryshire	No	
Dairy Equipment	Chaff cutter	Yes	Its an electric 3 blade chaff cutter
	Milking machine	No	
Other livestock species	Goats	Yes	They are kept under intensive production system hence promoting climate smartness
	Chicken	Yes	A 7,000-broiler unit is functional
Farm structures		Yes	There are homestead, dairy unit and storage facilities
Farm workers		Yes	1 Permanent labour and 2 contract labourers

2.8 Household characteristics:

The household data revealed youth participation in dairy production, women participation in both dairy production and decision-making processes and general household characteristics that influence implementation of climate smart agriculture and other new innovations at plot level. In addition, independent t-tests results were noted in table 6 for significant differences.

Table 6: Levene's tests results on household characteristics

	Levene's Tests		
		P Value	Conclusion
Fig 15	Farmer age category	0.757	There is no significant difference between the two sub-counties
Fig 19	Source of income	0.15	There is no significant difference between the two sub-counties
Fig 20	Plot labour availability	0.296	There is no significant difference between the two sub-counties
Fig 21	Family labour	0.838	There is no significant difference between the two sub-counties

- All Levene's test results are in the annex

The average age group of household heads of interviewed farmers for both sub-counties is 52.8 years with a standard deviation of 12.5 years. There In Ruiru, most farmers are less than 55 years of age whilst in Githunguri, most farmers are above 46 years old. There is no significant differences between ages of farmers of the two sub-counties. This is shown in fig 15.

Youths are involved in Smallholder dairy projects with less than 14% for both Sub-counties. However, youths in Ruiru have a 6% margin higher than those in Githunguri. This reflects on the possible adoption rate of CSA and longevity of smallholder dairy farming in both sub-counties.

Figure 15:Farmer categories by age

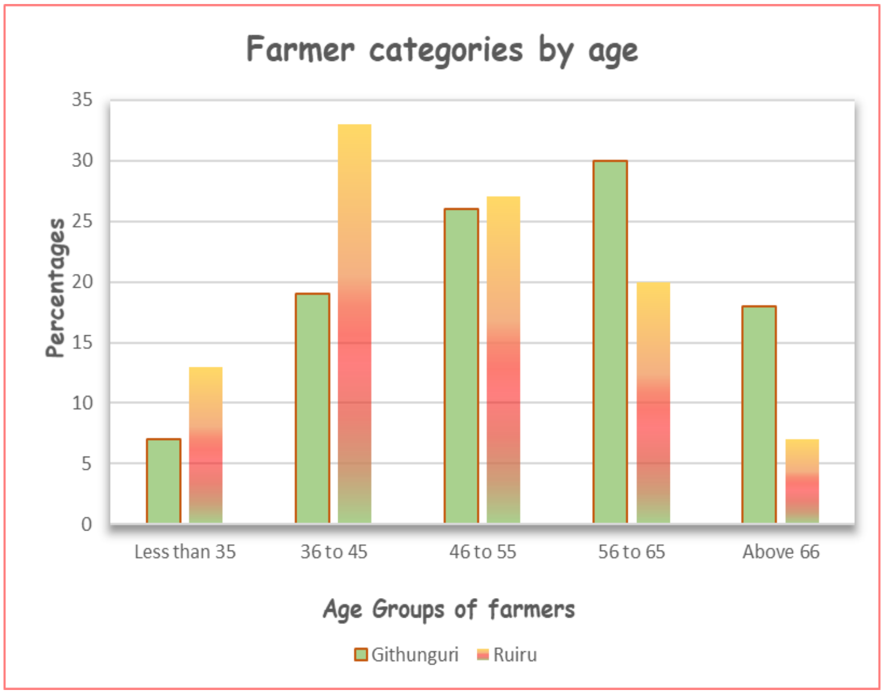
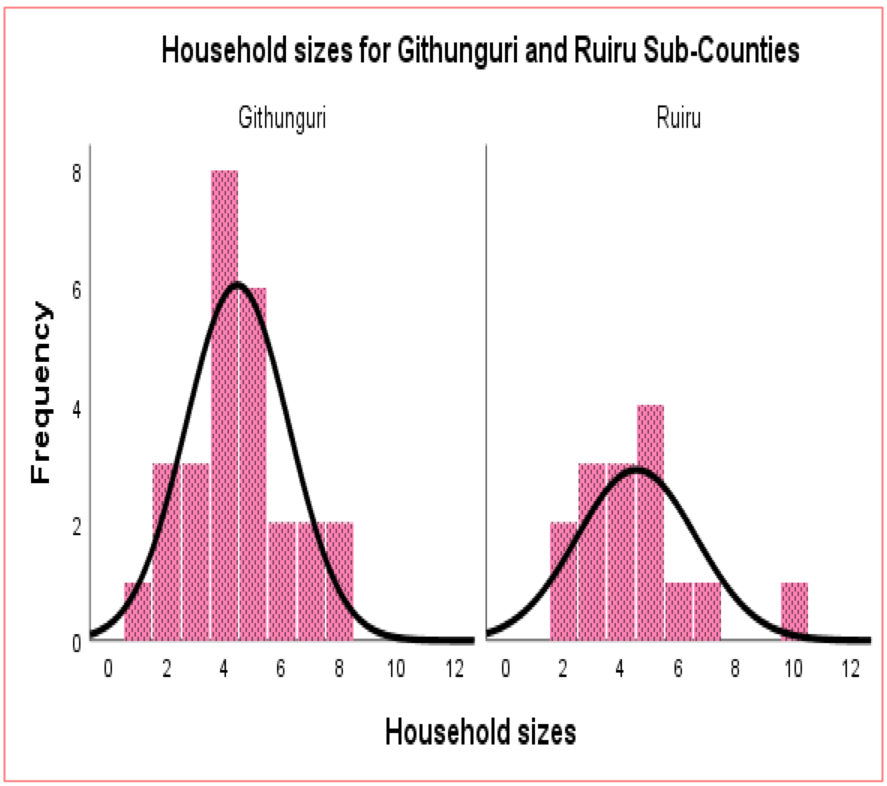


Figure 16: Household size



With reference to fig 16, the average household size for the two sub-counties is 4, with a standard deviation of 1.8. The modal house hold sizes are 4 and 5 for Githunguri and Ruiru sub-counties respectively.

The graphs reflect on the normal distribution of our sample from both sub-counties. The household sizes reflect on the need to manage feed production to protect our environment whilst maximizing production since most children are also starting dairy units on their parents homestead.

For both Githunguri and Ruiru sub-counties, married household heads constitute 85% and 87% respectively. 4% of the Household heads in Githunguri were single whilst no similar status was interviewed in Ruiru as shown in figure 17.

Figure 17: Marital status of household heads

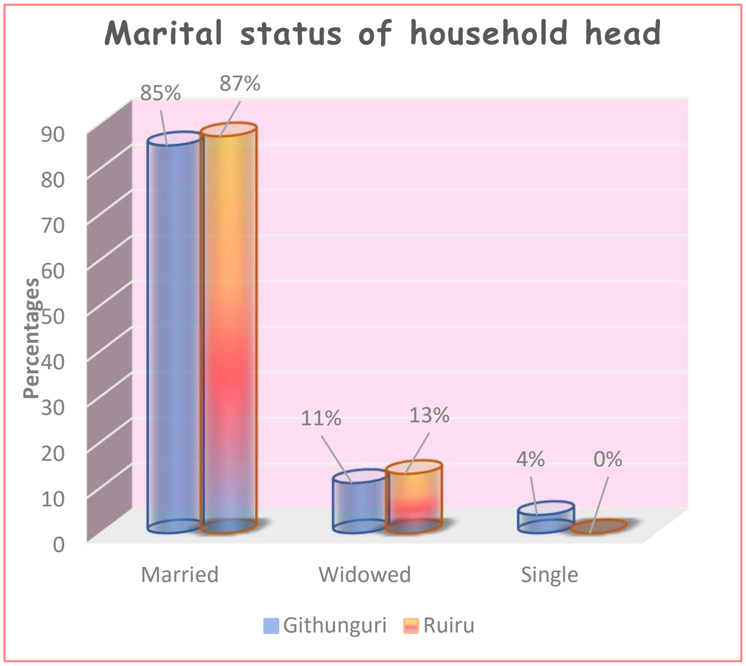
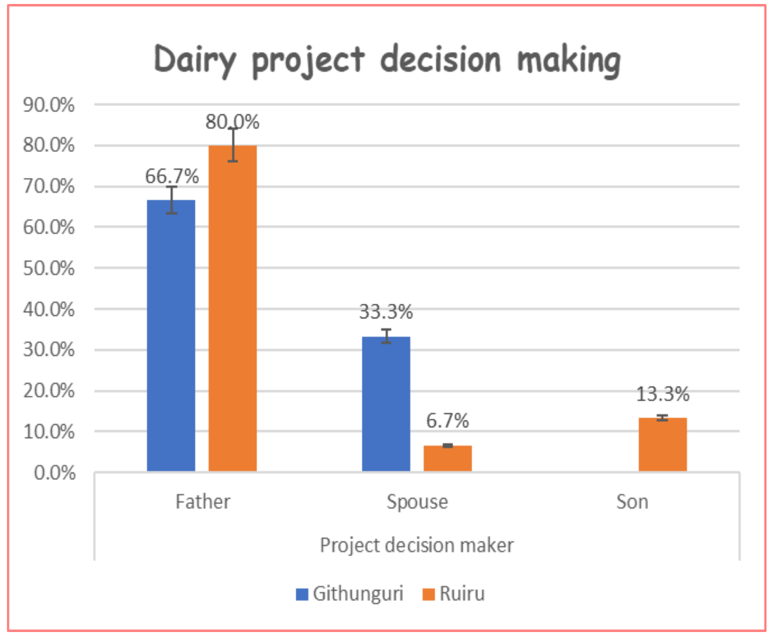
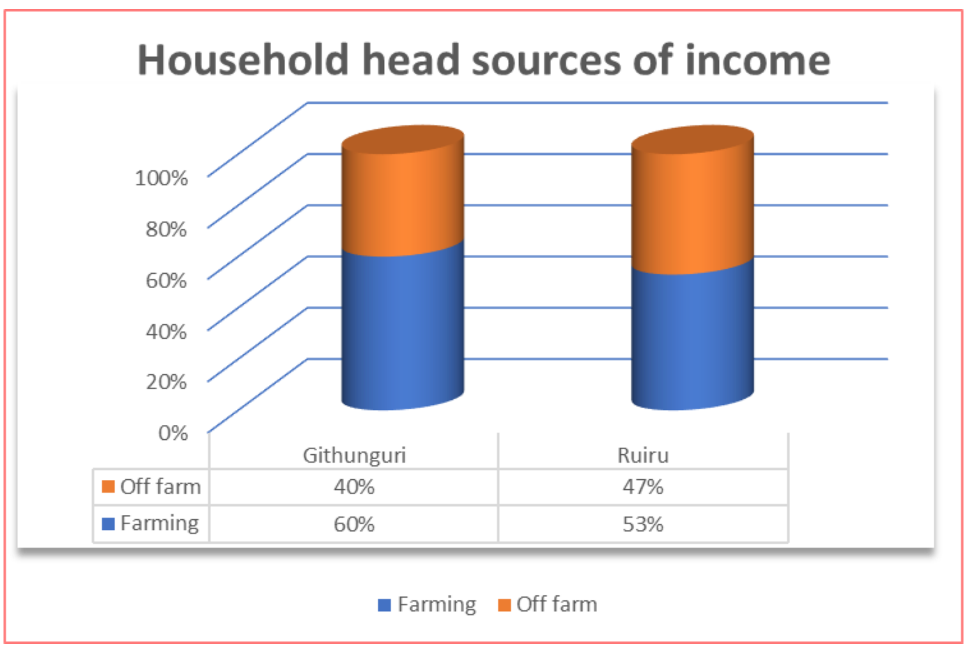


Figure 18:Dairy project decision making



In Githunguri sub-county only a third of women make independent decisions in the dairy projects as shown in figure 18. The patriarchal system is more in Ruiru where 80% of men make decisions in the dairy projects. Commendable is the 13% involvement of sons in decision making in Ruiru sub-county.

Figure 19:Household head primary occupation



In addition to that, not all decision makers are full time on the dairy project as shown on fig 19. 40% and 47% of household heads in Githunguri and Ruiru sub-counties respectively, have off farm businesses as their primary occupation. There is no significant difference between the two sub-counties.

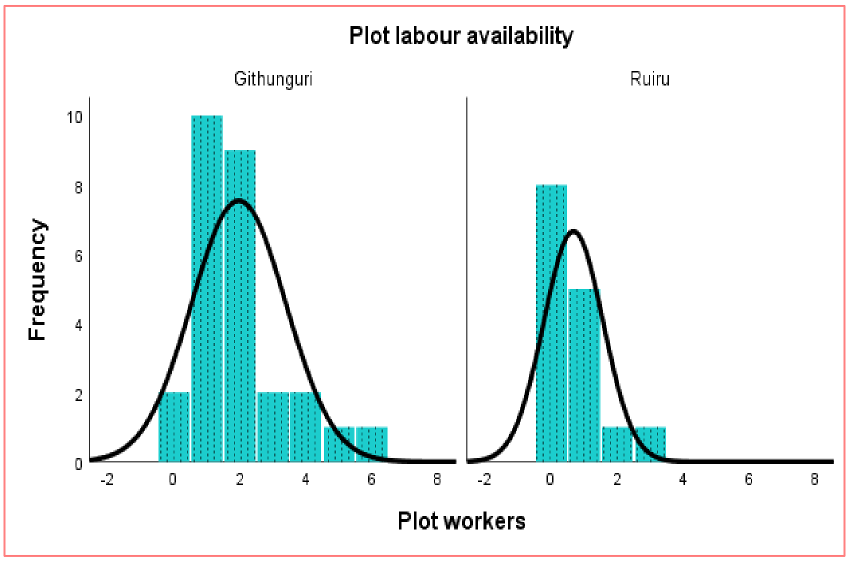
This has a bearing on the implementation of climate smart agriculture interventions and the adoption rate of potential climate mitigation strategies.

Table 7: Level of education

Highest level of education					
	Primary	Secondary	College	University	Adult education
Githunguri	18%	52%	15%	11%	4%
Ruiru	60%	20%	7%	13%	

As shown in table 7, a high number of farmers in Githunguri sub-county reached secondary level whilst in Ruiru 60% reached primary education. This makes sharing of climate smart agriculture ideas and literature easy and pamphlets can be distributed for future use.

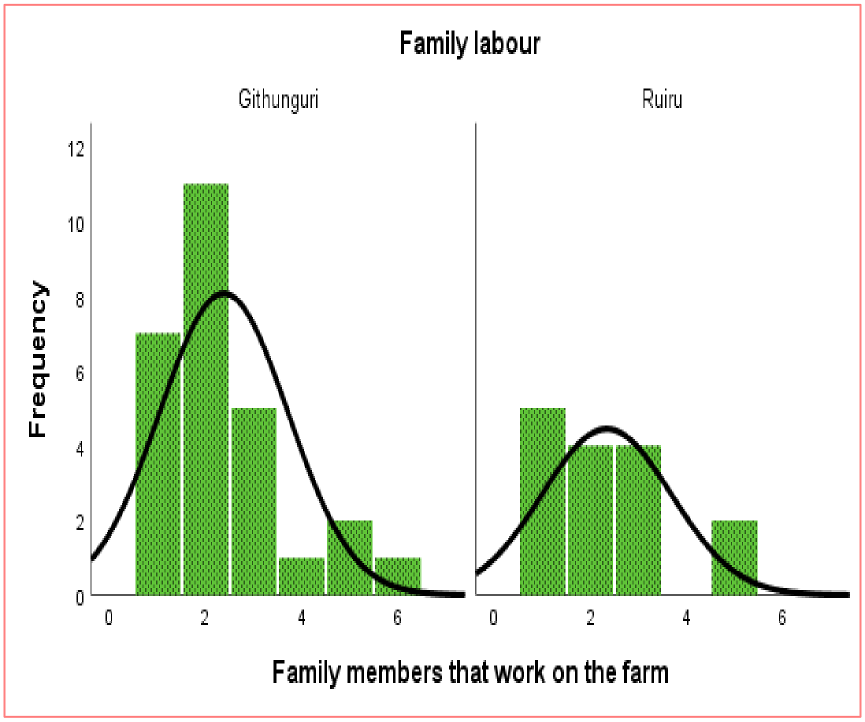
Figure 20: Plot labour availability



The labour mean for both sub-counties per plot is 1.5 persons, with a standard deviation of 1.4. Its statistically conclusive that, there is no significance difference between Githunguri and Ruiru sub-counties in plot labour available. Hence climate smart practices can be practiced using available labour on these small plots of land.

Plots without dairy unit labourers are more in Ruiru sub-county where women remain at the plot and do all the dairy unit duties.

Figure 21: Family labour



As shown in fig 21, most farmers in both sub-counties depend on family labour. In Githunguri the mode of household members labour reinforcement on the plot is 2, whilst in Riuru the mode is 1. There is no significance difference between Githunguri and Ruiru sub-counties in family labour available.

Participation of families on plot activities makes it easy to integrate climate smart practices since monitoring and passionate implementation from the project manager is available.

2.9 Dairy unit characteristics:

The following production parameters were analysed; dairy cattle breeds, proportion of dairy animals by class, calving interval, Number of milking cows, amount of milk produced.

Table 8: Dairy breeds

Dairy cattle breeds				
	Holstein	Aryshire	Holstein and Aryshire	Cross breeds
Githunguri	96%	0	4%	0
Ruiru	66%	7%	7%	20%

Githunguri sub-county has only 4% of the households with a mixture of Holstein and Aryshire breeds whilst the rest have Holstein Friesland dairy breeds. On the contrary, Ruiru has 20% of its farmers using cross breeds which they themselves can hardly identify to a particular breed. This is shown in table 8.

Table 9: Proportion of dairy animals buy class

Propotion of dairy animals by class							
	Bulls	Milking_cows	Dry_cows	Heifers	Steers	Weaners	Calves
Githunguri	6%	57%	14%	16%		10%	11%
Ruiru	8%	48%	7%	18%	1%	11%	7%

As shown in table 9, milking cows in Githunguri sub-county constitute a higher percentage, 57%, compared to 48% for Ruiru. However, Ruiru had less percentage of dry cows than Githunguri having 7% and 14% respectively. This distribution of livestock classes has a bearing on the climate change mitigation at farm level.

The mean values for parameters highlighted in table 10 were tested using single tailed t-test for any significant differences.

Table 10: Levene's tests results on household characteristics

	Levene's Tests		
		P Value	Conclusion
Fig 22	Mean number of dairy animals	0.003	There is significant difference between the two sub-counties
Fig 23	Mean number of milking animals	0.004	There is significant difference between the two sub-counties
Fig 24	Mean calving interval	0.006	There is significant difference between the two sub-counties
Fig 25	Mean peak milk production	0.001	There is significant difference between the two sub-counties

- All Levene's test results are in the annex;

Figure 22: Mean number of dairy animals

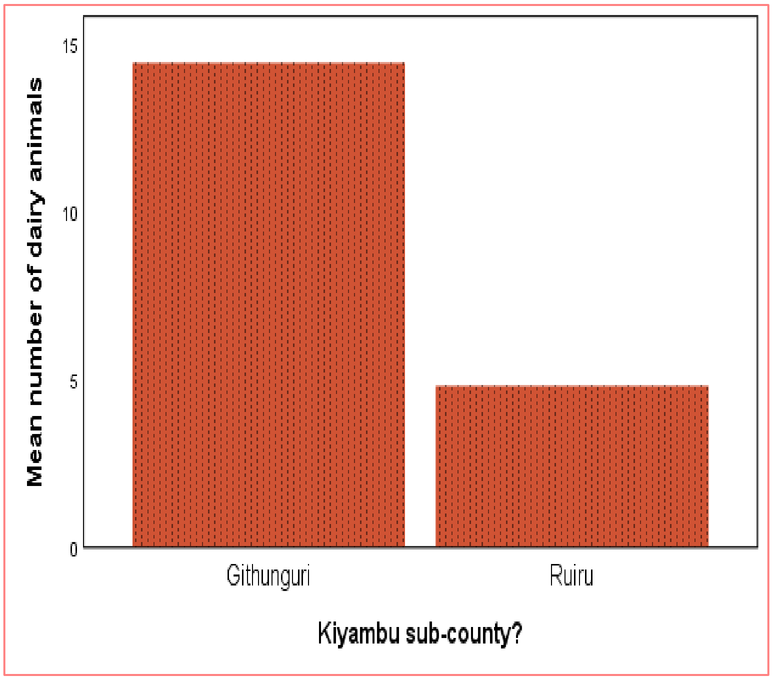
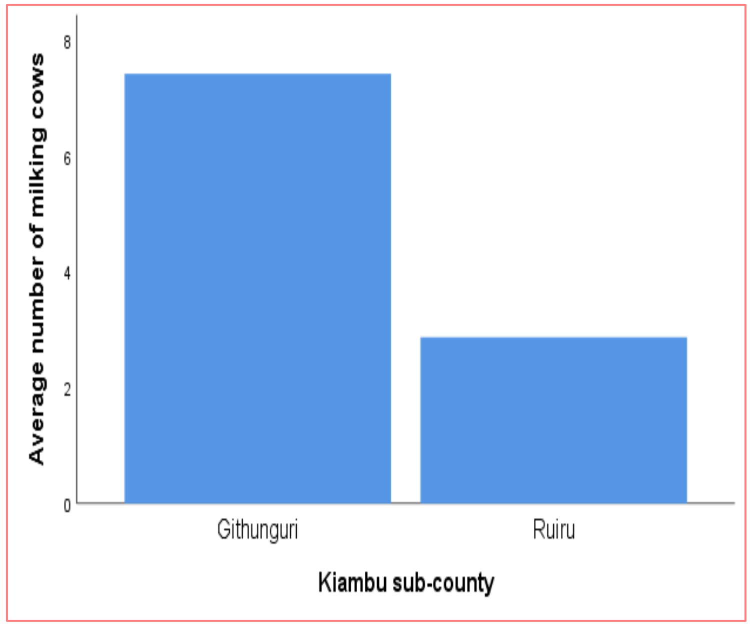
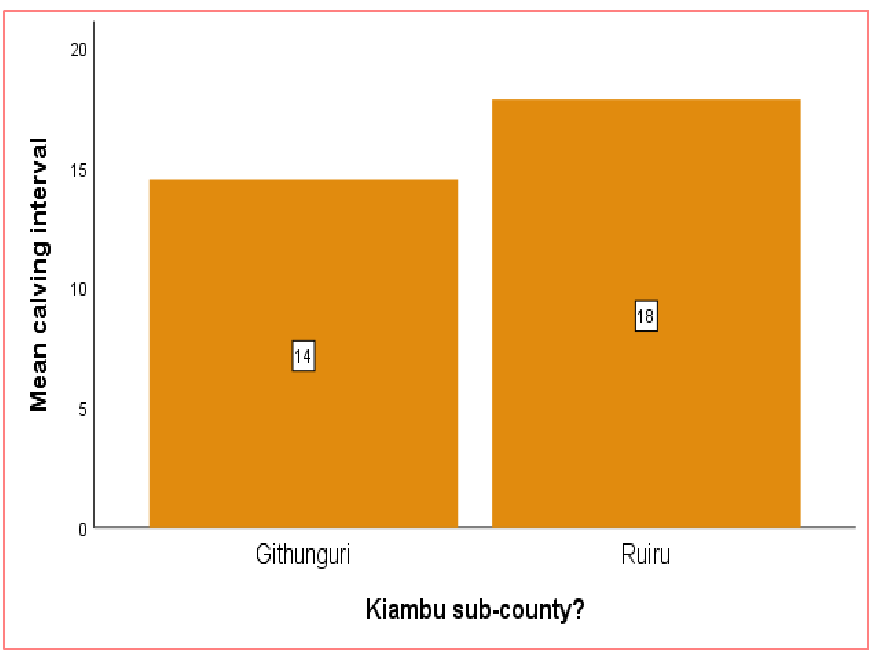


Figure 23: Mean number of milking cows



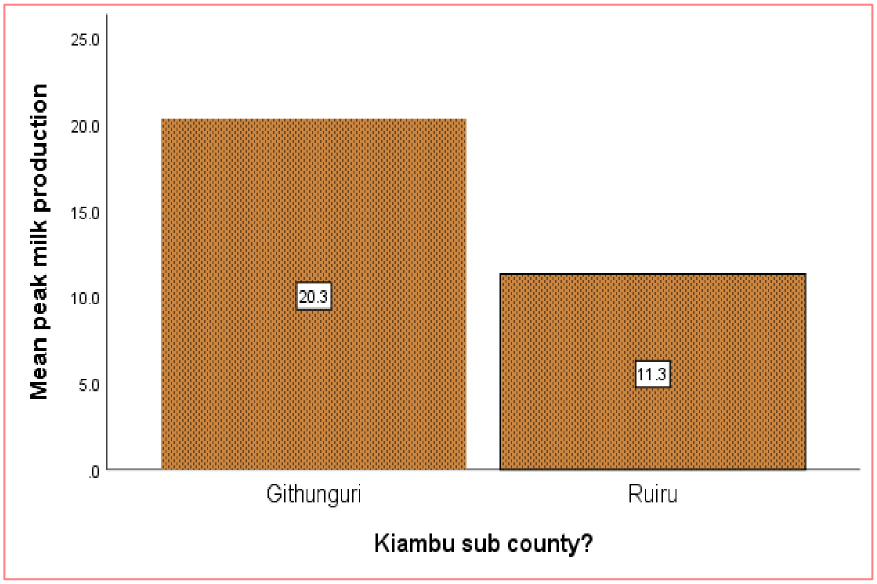
From figure22 and 23, we conclude that the average number of dairy animals and number of milking cows in Ruiru is less than that of Githunguri. In addition to that, Levene's tests states that there is significance difference on both the number of dairy animals and milking cows between the two sub-counties. Thus, integration of climate smart should be more intense in Githunguri where there is more livestock and high demand of feed and in Ruiru climate smart interventions need to have sound production parameters addressed for farmers to appreciate viability of the dairy sector.

Figure 24: Calving interval graph



As exhibited on graphical presentation of calving intervals in fig 24, there is significant difference between the two sub-counties. Hence CSD practices that reduces calving interval to 1 calf per year per cow are critical for both sub-counties.

Figure 25: Mean peak milk production graph



As shown on fig 25, there is a significant difference on the milk production between the two sub-counties. Githunguri farmers are producing more milk hence, there is need of dairy feed security for Ruiru farmers for them to increase milk production. This is achievable through implementation of climate smart agronomic practices.

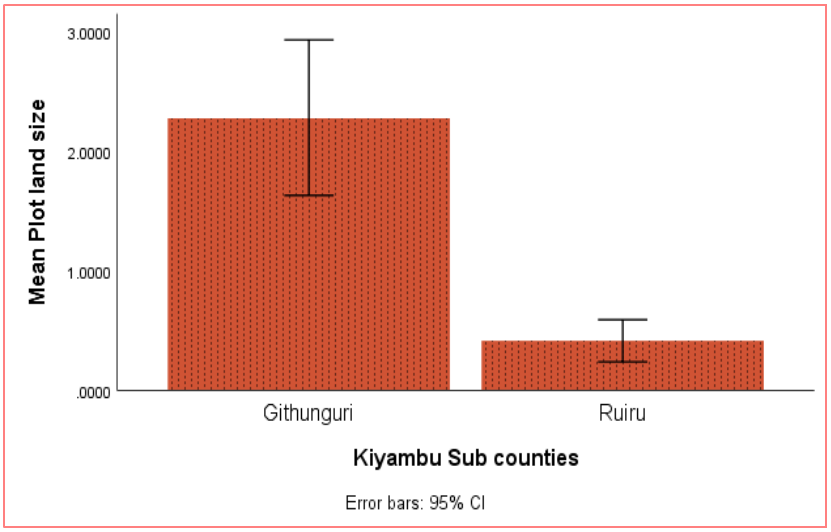
2.10 Fodder characteristics:

Table 11: Levene's tests results on household characteristics

	Levene's Tests		
		P Value	Conclusion
Fig 26	Mean plot land size	0.001	There is significant difference between the two sub-counties
Fig 27	Napier field size	0.146	There is no significant difference between the two sub-counties

- All Levene's test results are in the annex

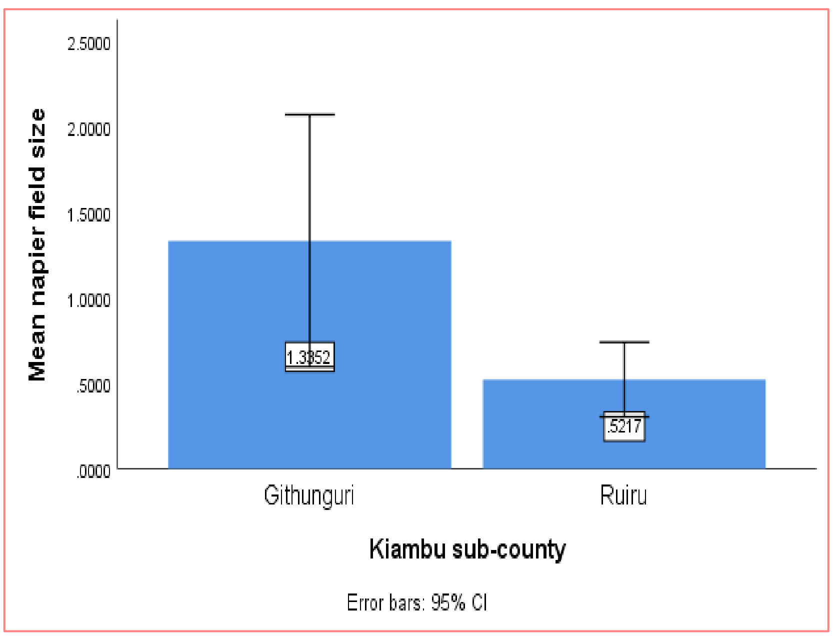
Figure 26: Mean plot land size



As shown in fig 26, there is a significant difference between plot sizes in Githunguri and Ruiru sub-counties. For both sub-counties the mean land size is 1.6 acre with a standard deviation of 1.6.

Hence integration of climate smart agriculture is critical in both sub-counties to increase the longevity of both finite and infinite natural resources on plots and reduce GHG emissions. Thus, sustainable production is to be promoted on the small highly productive pieces of lands.

Figure 27: Napier field size



Although there is significant difference in plot sizes between the two sub-counties, there is **no significant** difference in plot size set aside for napier growth.

For both sub-counties, the mean size of Napier field is 1.0 acre with a standard deviation of 1.6. Ruiru has smaller Napier fields averaging 0.5 acres due to its smaller average land sizes. Hence, most farmers have resorted to outsourcing fodder for their dairy animals. This is not economical at small scale but with integration of climate smart agronomic practices, it is possible for them to be feed secure.

Napier

Due to small land sizes, farmers have resorted to renting small plots of land for fodder production. For both sub-counties, 52.6% confirmed that they rent plots for fodder production. Interestingly, 5.3% of farmers do not practice zero grazing but rather depend on forest land for grazing their animals. However, less than 43% have other alternative means of securing fodder security all year round. This is shown on fig 14. Dairy animals that feed in the forestry area are predisposed to diseases increasing antibiotic use. Hence, CSA practices that reduce exposure of dairy animals to parasites and pathogens is commendable. Rented plots can be effective if climate smart practices are implemented hence sustainably increasing yield for the dairy unit.

Figure 28: Plot rentals for fodder

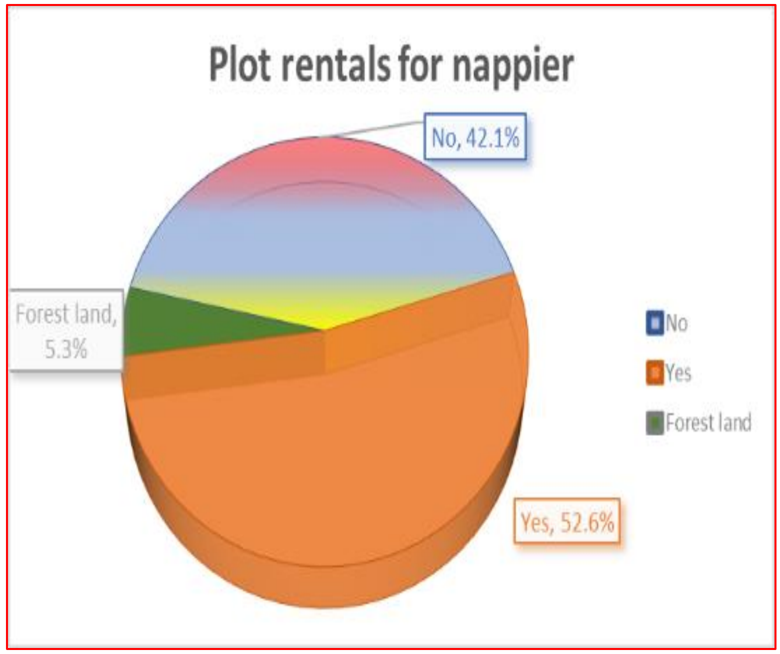
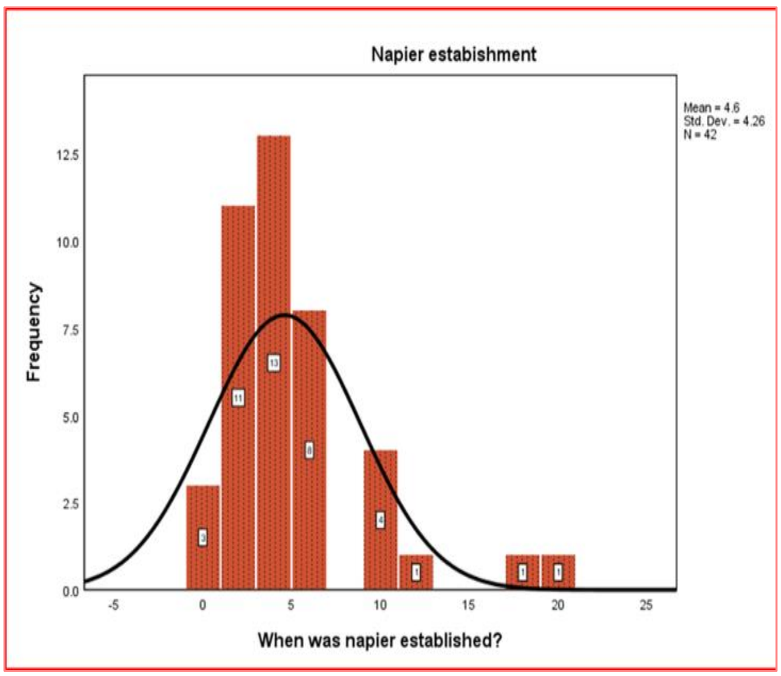


Figure 29: Napier establishment



After producing their feed, most farmers use cut and carry method of feeding their dairy animals. This is confirmed by fig 29, which shows that most of the napier fields were established more than 4 years ago. The mean number of years is 4.6 years with a standard deviation of 4.26.

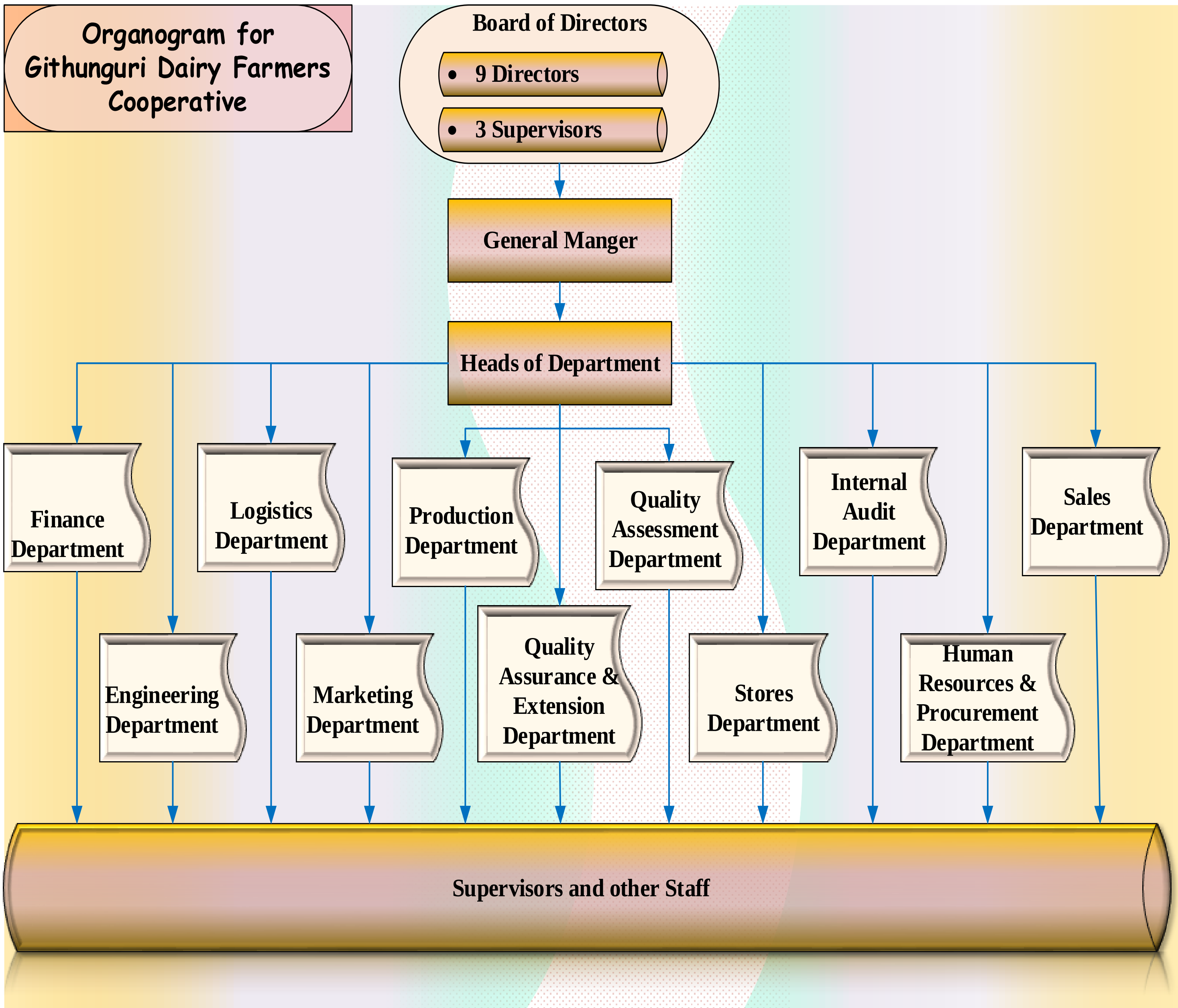
2.11 Gender on climate change and dairy production

Many women running projects in Ruiru are not trained and don't attend trainings as trainings are for members only which is their husbands. Hence women are not equipped for sustainable climate smart dairy production. For Githunguri most women are empowered, since they are then ones registered with the cooperative, though men are the Household heads and decision makers.

2.12 The Githunguri Farmer's Cooperative:

This Cooperative of farmers is well structured to give service to farmers whilst maintaining its competitiveness on the market. The Cooperative is wholly owned by farmers who set up a board to manage the cooperative and give them progress reports. The organogram is as shown in fig 30.

Figure 30: Organogram of Githunguri Farmers' Cooperative

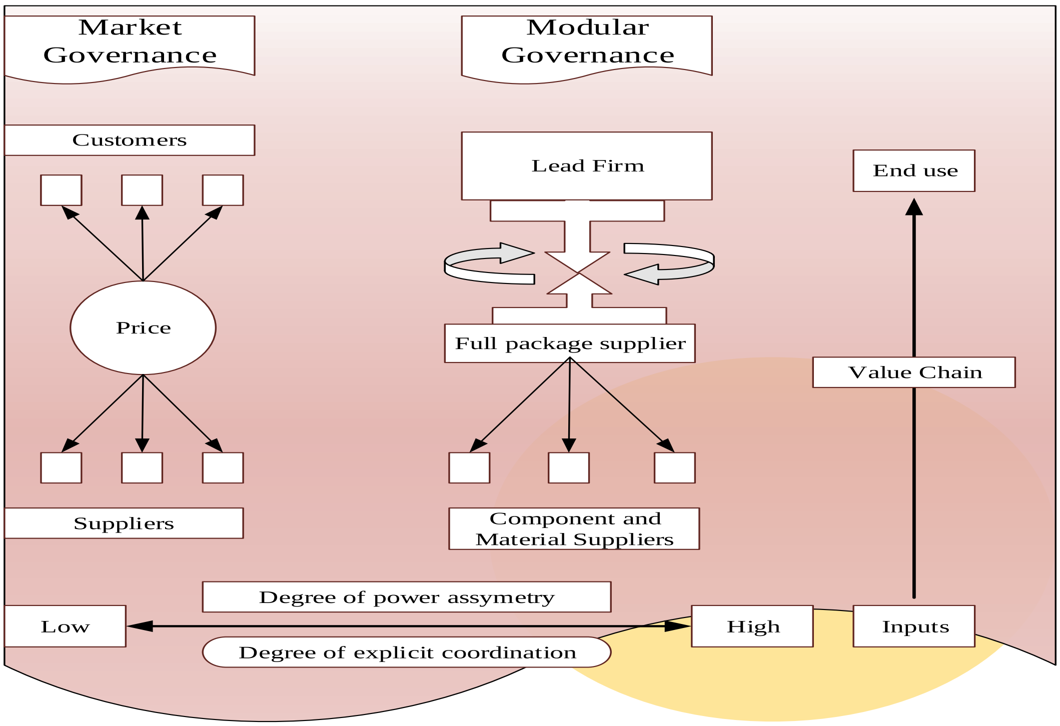


Source (Author., 2018)

2.13 Feed value chain governance

After evaluating the instruments of governance which include; contracts between value chain actors, product standardization, organizational management and government regulatory frameworks among others, we have concluded that the feed value chain is governed though market and modular types.

Figure 31: Feed value chain governance



Source (Author., 2018)

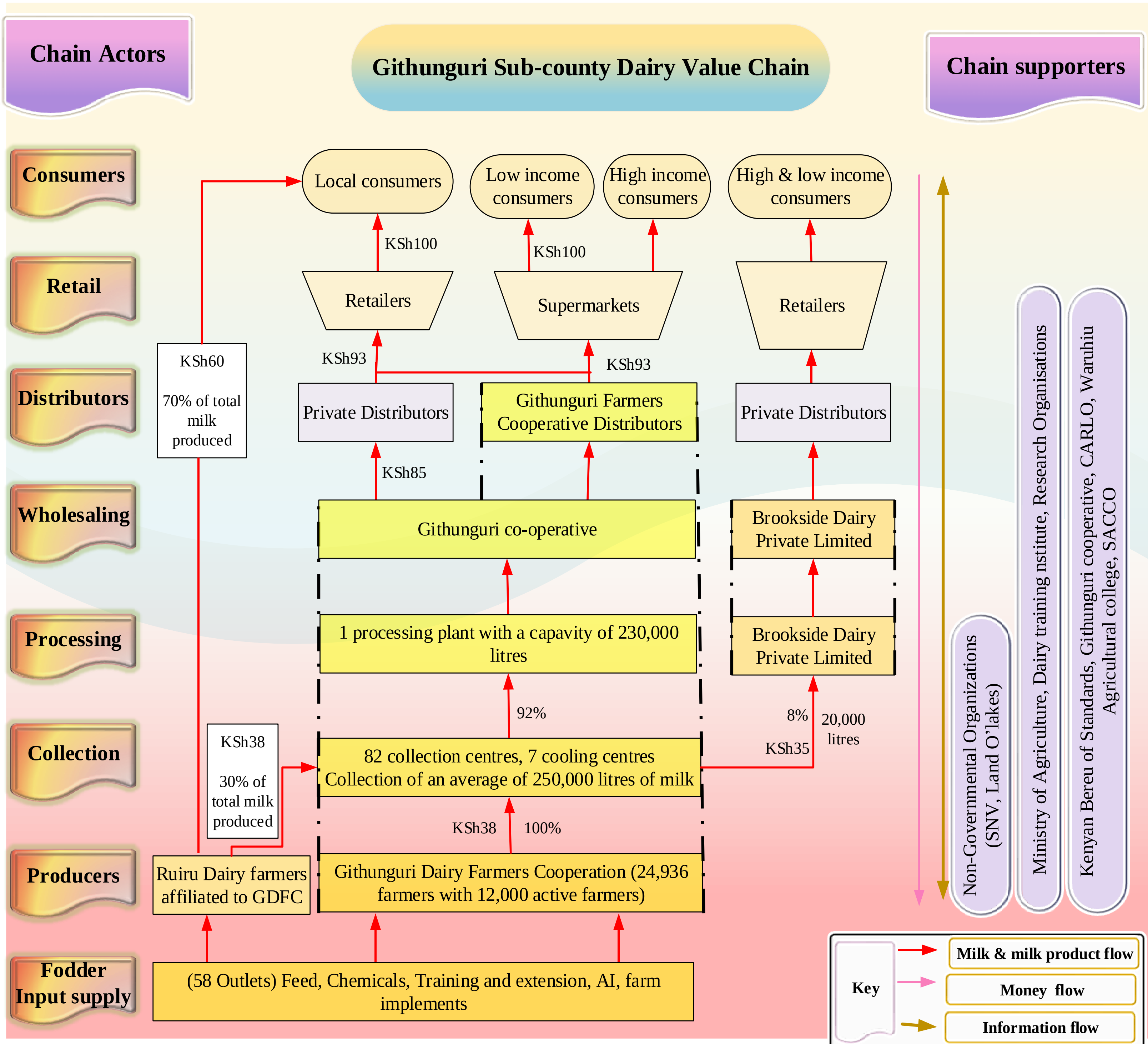
The feed value chain is controlled by both market and modular type of governance. In addition, the milk value chain is modular governed. There are no any transactional costs involved in farmers switching from one trader to the other and there are no binding contracts with any of the feed providers. Information sharing is limited as traders only provides information on types of products on offer but not detailed information on nutritive value and enhancement of dairy productivity in relation to the type of fodder on offer. The buyer has no influence on productivity of fodder and has very limited interest in standardization and certification of the product. All he wants is a standard size hay bale for selling. Interactions between traders and farmers is limited and no technical assistance to suppliers is provided. The central governance mechanism is price rather.

On the other hand, Githunguri Dairy farmer's Cooperative also sources fodder for their farmers and sells to them on a subsidized amount. They provide their farmers with standardized hay bales either on credit or cash. They source quality Boma Rhodes for maximum productivity of mall holder dairy production. The hay is distributed across the Cooperative retail shops for ease accessibility by farmers.

In addition to fodder, the cooperative also has a modular governance mode of the milk value chain. The Githunguri Dairy Farmer's Cooperative provides trucks for milk collection in every route. On every collection point is a grader who specifies the bench mark qualities and standards required. She/he conducts several tests including the organoleptic test, alcohol test and density test. The cooperative has a mandate to train farmers and assist them meet the required standards for the ultimate processing of milk.

2.14 Milk value chain

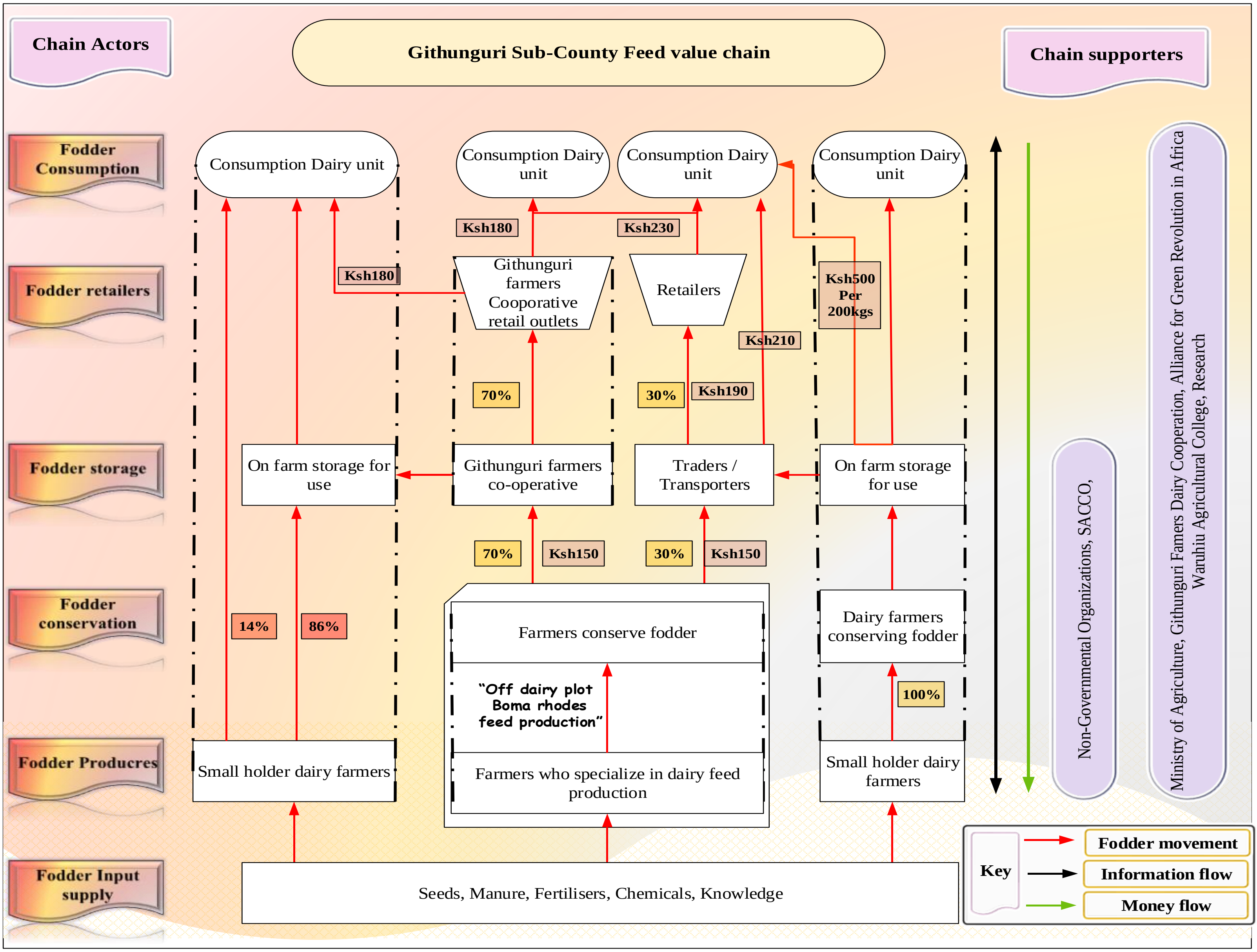
Figure 32: Milk Value chain



Source (Author, 2018)

2.15 Feed value chain

Figure 33: Feed value chain

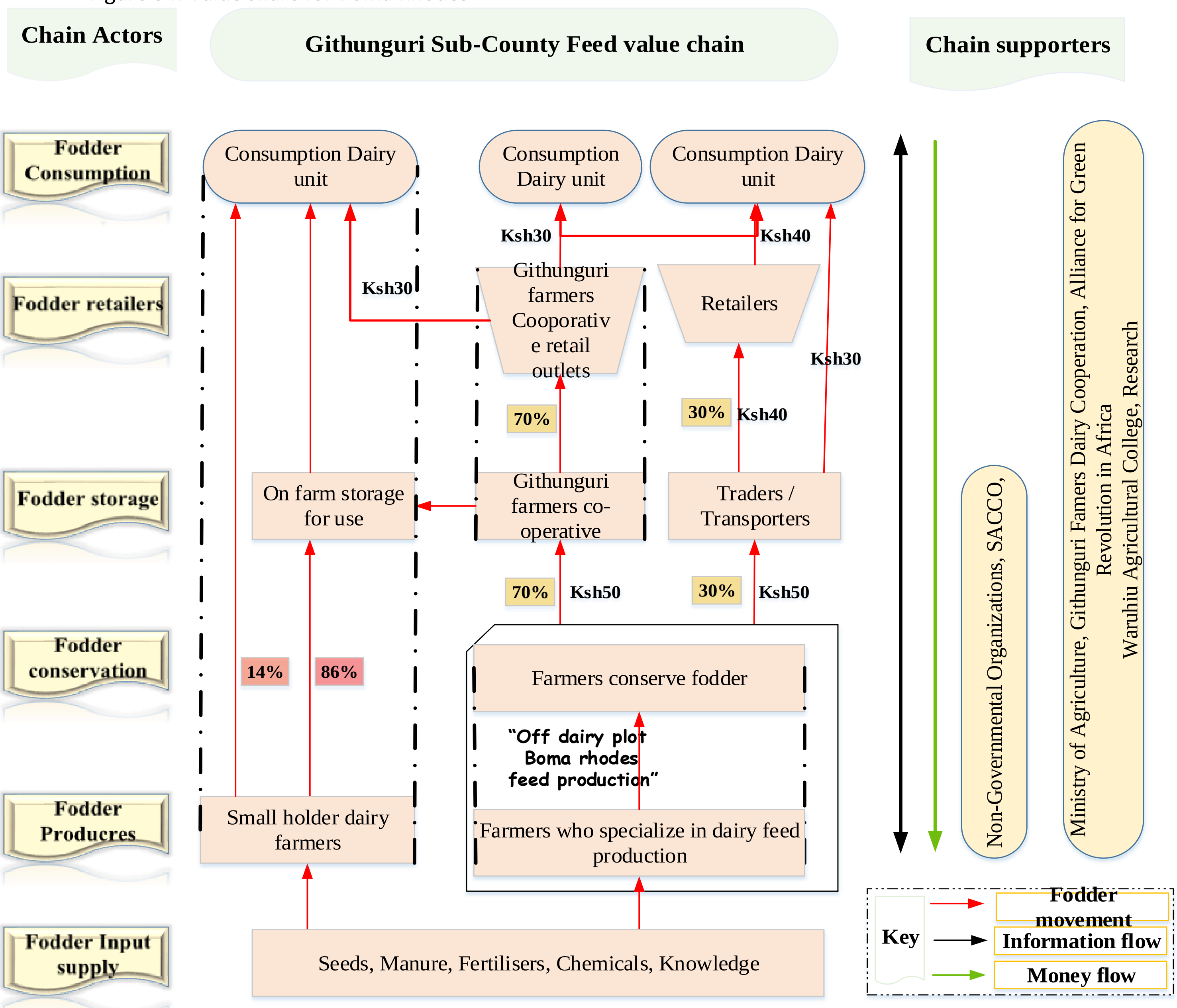


Source (Author., 2018)

The price of hay or Boma Rhodes fluctuates throughout the year. During the drought period, hay ranges between KES 250 to 300 per bale, making this a relatively expensive investment for most small holder farmers. In non-drought periods with greater supply, prices fall to as low as KSH 150/bale. With an increased and more constant supply of hay from farmers who specialize in hay production, its safely predicted that prices could fall to around KSH 100/bale. On the contrary, farmers can produce their own feed and conserve it hence reducing on feed expense and greenhouse gas emissions.

2.16 Value share for Boma Rhodes

Figure 34: Value share for Boma Rhodes



Source (Author., 2018)

Boma Rhodes is the most nutritive grass on the market in Githunguri and Ruiru sub-counties. It is the only grass that the GDFCS buys for its farmers. It is climate smart also due to its high digestibility.

2.17 Fodder profitability

Napier is the main feed type available. However, the GDFCS is planning to promote growth of maize instead of Napier and the gross margin is as shown in table 11.

Table 11:Gross margin budget

Gross margin budget			
	Napier		**Maize**
Gross output	50,400.00		94,200.00
Variable costs	17,600.00		44,890.00
Gross margin	**32,800.00**		**49,310.00**
Depreciation and Interest	35,200.00		10,720.00
Net income	**29,233.33**		**38,590.00**

*See annex for the whole budget

2.18 Support services information sharing

The GDFCS has a strong extension support for its farmers. They have well trained extension workers who deliver on their mandate due to sound mobility. Extension services is equipped with brand new motorcycles for cascading quality information to the cooperative stakeholders (farmers). Farmers interviewed shared the following information.

Figure 35: Dairy farmer trainers

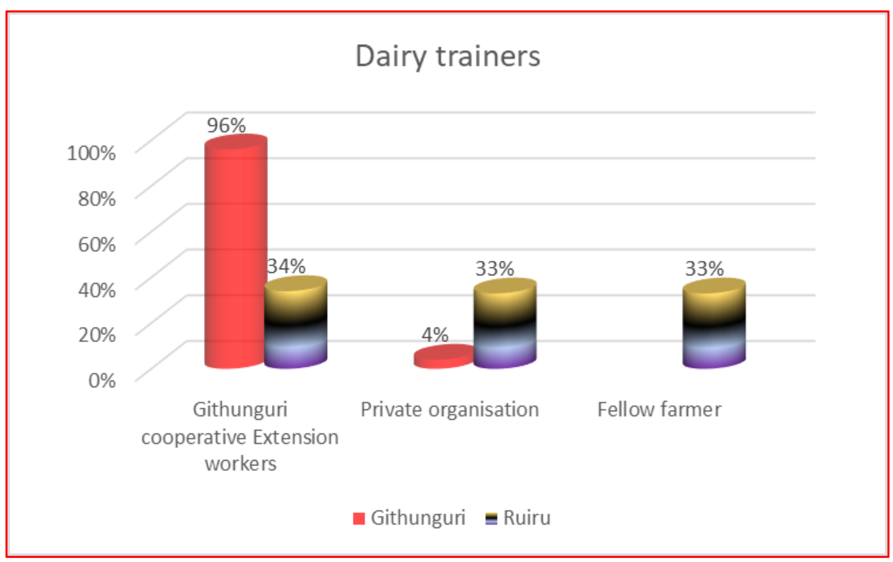


Table 12: Dairy farmer trainings

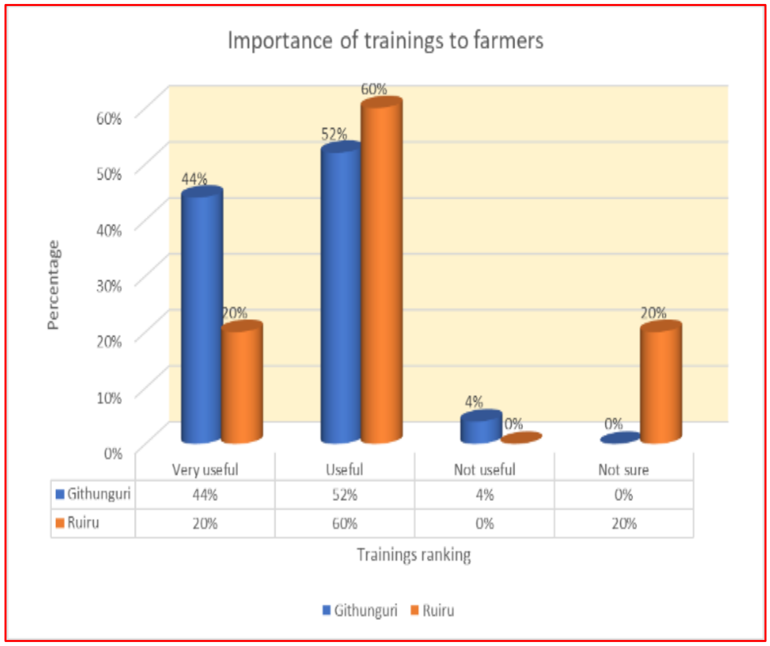
Trainings		
Githunguri	Yes	100%
Ruiru	Yes	80%

All the farmers in Githunguri received formal trainings as shown in fig 35 above. However, 96% were trained by GDFC whilst 4% pointed to the private organization for delivery of formal trainings. On the contrary, 20% of households in Ruiru testified that they have not received formal trainings as shown on fig 35. However, those that were trained received trainings from GDFCS, private organizations and lead farmers. The 20% who did not receive formal trainings rely on the fellow farmers as shown on table 11. 13% were formally trained by lead farmers. Unfortunately, the trainings did not single out CSA but emphasized on good agricultural practices. It's possible to disseminate CSA trainings using same training platforms.

The trainings given to farmers were rated differently according to farmer's perspective. 44% of farmers in Githunguri said the trainings were very useful whilst only 20% of those in Ruiru said the same. Only 4% in Githunguri said the trainings were not useful and 20% of the farmers in Ruiru who never got formal trainings were not sure of the importance of the trainings. The rest of the farmers are satisfied with the trainings they are receiving.

Unfortunately, CSA was a foreign topic to the farmers hence there is need to incorporate it in their trainings and it will be beneficial to them. The GDFCS does its trainings since it is equipped with both competent human resources, trainings materials and resources to service all farmers. It gets assistance from Government on vaccinations and organized route trainings upon request.

Figure 36: Importance of farmer training



2.19 Climate-smart practices useful in smallholder agricultural production

The first stakeholder meeting with farmers revealed the various Climate smart agriculture practices they practice on their plots. Table 13 is a summation of the FGD results.

Table 13: Climate smart agriculture practices

Crop management	**Livestock management**	**Soil and water management**	**Agroforestry**	**Integrated food energy systems**
• Intercropping with legumes • Crop rotations • New crop varieties (e.g. drought resistant) • Improved storage and processing techniques • Greater crop diversity	• Improved feeding strategies (e.g. cut 'n carry) • Fodder crops • Manure treatment • Improved livestock health • Animal husbandry improvements	• Conservation agriculture (e.g. minimum tillage) • Contour planting • Terraces and bunds • Planting pits • Water storage (e.g. water pans)	• Boundary trees and hedgerows • Nitrogen-fixing trees on farms • Multipurpose trees • Woodlots • Fruit orchards	• Biogas • Improved stoves

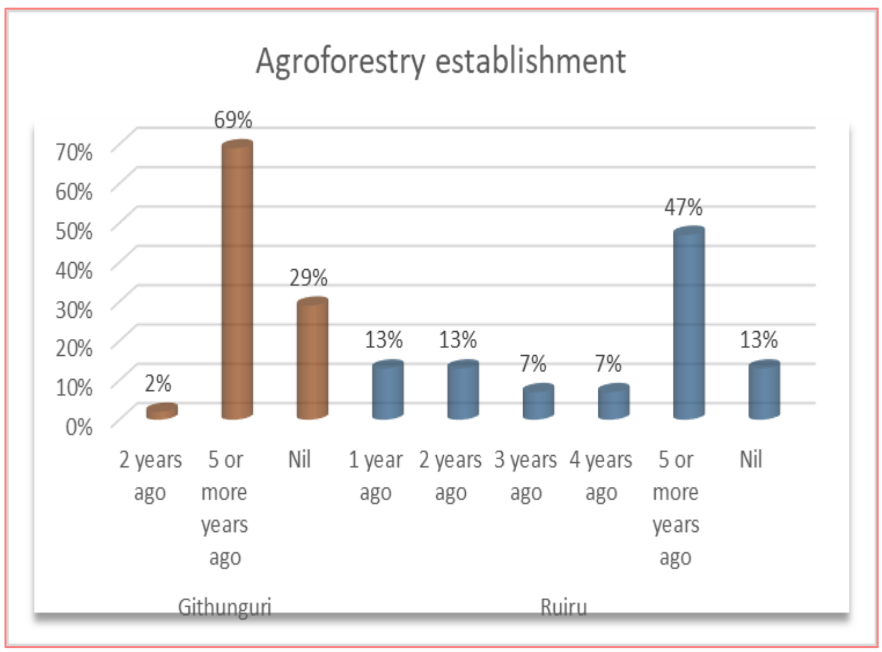
After administering the questionnaire to the farmers, the following results were noted on CSA.

Table 14: Climate smart agriculture practices

	Climate Smart Agriculture prctices/indictaors													
	Zero grazing		Agroforestry		Crop rotaion		Minimum tillage		Water harvesting		Soil analysis		Fertiliser usage	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Githunguri	93%	7%	78%	22%	37%	63%	89%	11%	59%	41%		100%	41%	59%
Ruiru	100%		80%	20%	27%	73%	87%	13%	67%	33%		100%	13%	87%

Zero grazing - All farmers in Ruiru are practicing zero grazing and this has been the solution to small land sizes. However, Githunguri farmers also have small land sizes but 7% of them send their dairy animals to graze in the forest area for a fee.

Figure 37:Agroforestry establishment



Agroforestry - Farmers in both Githunguri and Ruiru practice Agroforestry. However, 69% of the trees in Githunguri were planted more than 5 years ago whilst 29 percent of farmers did not plant any trees on their plots. Ruiru is an upcoming city and farmers are planting trees continuously. However, 47% of the farmers also have their trees planted more than 5 years ago. This is shown on fig 38.

Some had small plantations of Eucalyptus as source of income. Eucalyptus are harvested after 7 years. Grevilia were highly prioritized due to their ability to be intercropped with napier and other fodder crops without any negative impacts. However, most trees are planted on the periphery of the plot an on terraces.

Crop rotation – It is not highly practiced with 63% and 73% for Githunguri and Ruiru respectively. This is due to small land sizes and cut and carry method of Napier harvesting and feeding. The rotation is due to small portions of seasonal crops being planted on the plot.in addition to that, more than 87% of farmers in either Githunguri and Ruiru practice minimum tillage. In Napier fields there is no need for continuous cultivation because of its ability to ultimately cover the ground.

Water harvesting - 41% and 33% of farmers in Githunguri and Ruiru respectively, do not harvest water for storage and later use. With the critical importance of water resource, much has to be done to assist them harvest and store water for fodder production.

Figure 38: Fertiliser usage

	Fertiliser usage	
	Yes	No
Githunguri	59%	41%
Ruiru	87%	13%

Fertiliser usage and Soil analysis – 100% of farmers in both sub counties do not test their soils. Hence, they are not aware of the balance of nutrients in the soil after putting manure in the field. The Napier fields are the dumping site for manure for most farmers. Independent of the excess manure, farmers still put fertiliser especially in cereal crops like maize. They use it as top dressing. Tis is not a climate smart agronomic practice. Much extension needs to be done to increase use of manure in cereal crop production. However, the quantities used are very small (5kg/acre).

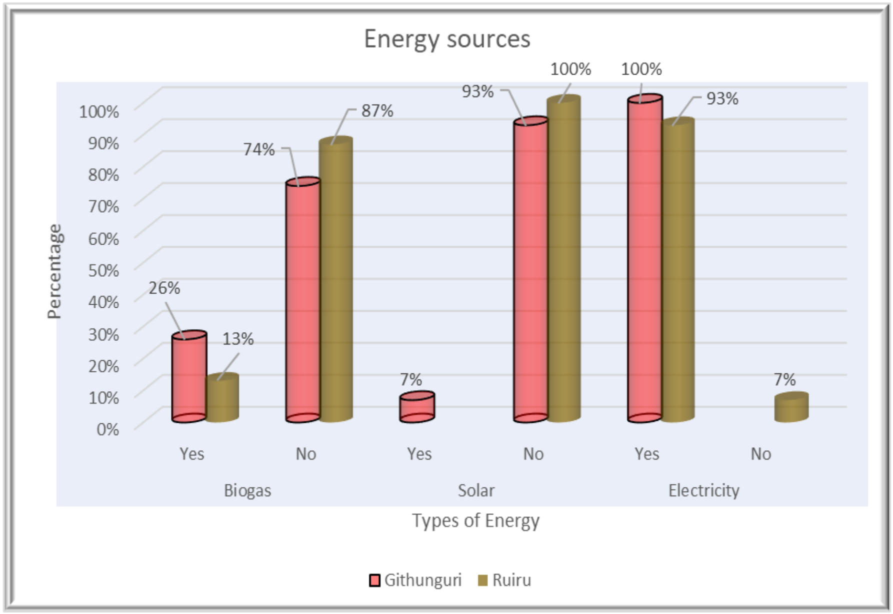
Figure 39:Manure management

Manure management - Manure is put in Napier fields ad_libitum with no soil analysis for farmers in both sub-counties. This results in excess nutrients in soil and this is not climate smart as most nutrients are lost via leaching

As shown in fig 39, some farmers don't collect manure but push them out of the kraal into nearby fields via a stream. This leads to loss of nutrients and improper distribution of manure in the fields. Some farmers dump manure out of their premises and manure is washed away by rain into water bodies leading to eutrophication. However, some are covering their manure, but they will be following an instruction by the extension worker without a broader understanding of climate smart agriculture. In addition to that, farmers are less knowledgeable about use of dried cow dung as bedding to reduce GHG emissions since manure has good absorbent properties compared to cow mats.

Antibiotic use - The use of anti-biotics is rampant on almost every plot. 74% and 67% of the farmers in Githunguri and Ruiru respectively, confirmed the problem of mastitis on their plots. Less than 35% of the farmers in both sub-counties acknowledged Rift valley fever and foot and mouth as challenges. In mastitis cases farmers prefer short acting antibiotics so that they quickly start to deliver milk to GDFCS. This has led to abuse of short acting drugs and potentially drug resistance.

Figure 40: Energy source



Energy - Its clearly shown in fig 40, that use of biogas by farmers is still very low. Also, solar power usage is low. Most farmers are preferring electricity. Its more economic and climate smart to use biogas hence the proposed business model supports this informed advice.

Table 15: Feed transportation means

Feed transportation means		
	Githunguri	Ruiru
Wheelbarrow	44%	20%
Motorbike	15%	33%
Car	41%	33%
Donkey cart		14%

Feed transport - Transport system, i.e cars and motorbikes, in fodder transportation use fuel hence contributing to climate change. This can be reduced through efficient cutting and carrying of fodder once in bulk with a large truck and making silage. Rather than cutting every 3 days and producing GHG emissions through production of CO and CO_2.

Figure 41: Feed transportation means

Donkey cart | Lorry | Motorcycle

2.20 The seasonality of farm feed production

Fodder production is influenced heavily by seasonality. Hence a study on the current season was instrumental in understanding the fodder challenges and preferences in relation to climate smartness. After a FGD with farmers and extension staff, the following table was drafted.

Table 16: Seasonality of feed production

	Months											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rainfall			**Long Rains**					**Drizzles with sun**			**Short rains**	
On plot feed Availability	**Scarce**		**Moderate**		**Excess**		**Moderate**			**scarce**	**Moderate**	**Sufficient**

Source: Focus group with farmers

NB: Short rains may start late October and in January it can rain for a day or two. However, in both October and January there are rarely wet pentads. July is the coldest month and September is totally dry.

During periods of scarce feed resource farmers have their strategies to cope with constant demand of feed by the dairy unit. The following strategies were suggested and ranked by farmers as ways of cushioning themselves from feed deficit. Strategy ranked 1 is the most used and the one ranked 6 is the least used and it's the last option to be implemented.

Table 17: Feed challenge strategy

Strategy	**Rank**
Feed on conserved feed e.g silage	1
Feed on crop residue e.g, maize stover	2
Buying feed from traders/ GDFC e.g hay	3
Buying concentrates	4
Harvesting grass from public land, river banks and neglected coffee plantations	5
Grazing on the forestry area	6

*They are listed in order of priority by farmers (1-most prioritized, 6-least prioritized)

To curb feed challenges and expensive concentrate alternatives, farmers use other supplementary dairy feed like those listed in table 18. However, pine apple, brewer's waste and poultry waste have a negative impact on the milk quality if fed in excess. The odour, colour, taste and quality of milk is reduced.

Table 18: Alternative feed sources

	Supplementary dairy feed											
	Minerals		Pine apple waste		Brewer's waste		Poultry waste		Maize gem		Dairy meal	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Githunguri	96%	4%	26%	74%	33%	67%	11%	89%	100%		100%	
Ruiru		100%	7%	93%	7%	93%		100%	87%	13%	100%	

2.20.1 Climate risk management

There is limited dissemination of information on climate risks and weather forecast during trainings. Farmers depend on media (television and radio) programs for constant update on meteorological weather advisories and weather forecasting. For preparedness and adaptation to climate change, climate risk management is critical. Climatic weather updates need to be in place to assist farmers to plan ahead and make informed decisions.

2.21 Potential Business Canvas model for introducing maize

Designing of efficient small holder dairy feed business model is imperative in showing feasibility of producing maize silage feed basing on existing feed proposal, and this could be developed to achieve production objectives. Such efforts will, in turn, translate into enhanced food security balanced with environmental sustainability. The following business model has thus been developed.

Table 19: Canvas business model for maize

<table>
<tr>
<td rowspan="2">Key Partners
6
• Takamoto biogas
• Ministry of Agriculture
• Agro-Vet Stores
• Research Centers
• John Deere
• SACCO
• KALRO
• Kenya Seed Co
• Insurance Co
• KCIC
• AGRA</td>
<td>Key Activities
7
• Trainings and exhibitions
• Linking farmers to biogas
• Manure composting demos
• Biogas installations & energy production
• Fodder production</td>
<td rowspan="2">Value Proposition
1
• High quality Milk production
• Climate Smart fodder (less carbon footprint)
• Quality product (high protein and energy feed)
• Sustainable and Climate smart energy source</td>
<td>Customer Relationships
4
• Trust
• Subsidized input supplies
• Extensionists
• Trainings on climate smart fodder production and conservation
• Word of mouth</td>
<td rowspan="2">Customer Segments
2
• Githunguri Smallholder dairy farmers</td>
</tr>
<tr>
<td>Key Resources
8
• Small holder dairy farmers
• Dairy cattle
• Manure
• Human resource
• Equipment (Biogas digester)</td>
<td>Channels
3
• Direct farm sales
• Distributors
• Githunguri Co-operative outlets</td>
</tr>
<tr>
<td colspan="3">Cost Structure
9
• Fodder input cost subsidy
• Fodder production cost
• Fodder processing and storage cost
• Depreciation and Maintenance cost (Buildings and equipment)
• Labour cost</td>
<td colspan="2">Revenue Streams
5
• Fodder sales
• Fodder seed sales
• Trainings and exhibitions
• Energy sales</td>
</tr>
</table>

Source: (Author., 2018), Adapted from (Osterwalder et al., *2010)*

Table 20: Functions of key partners

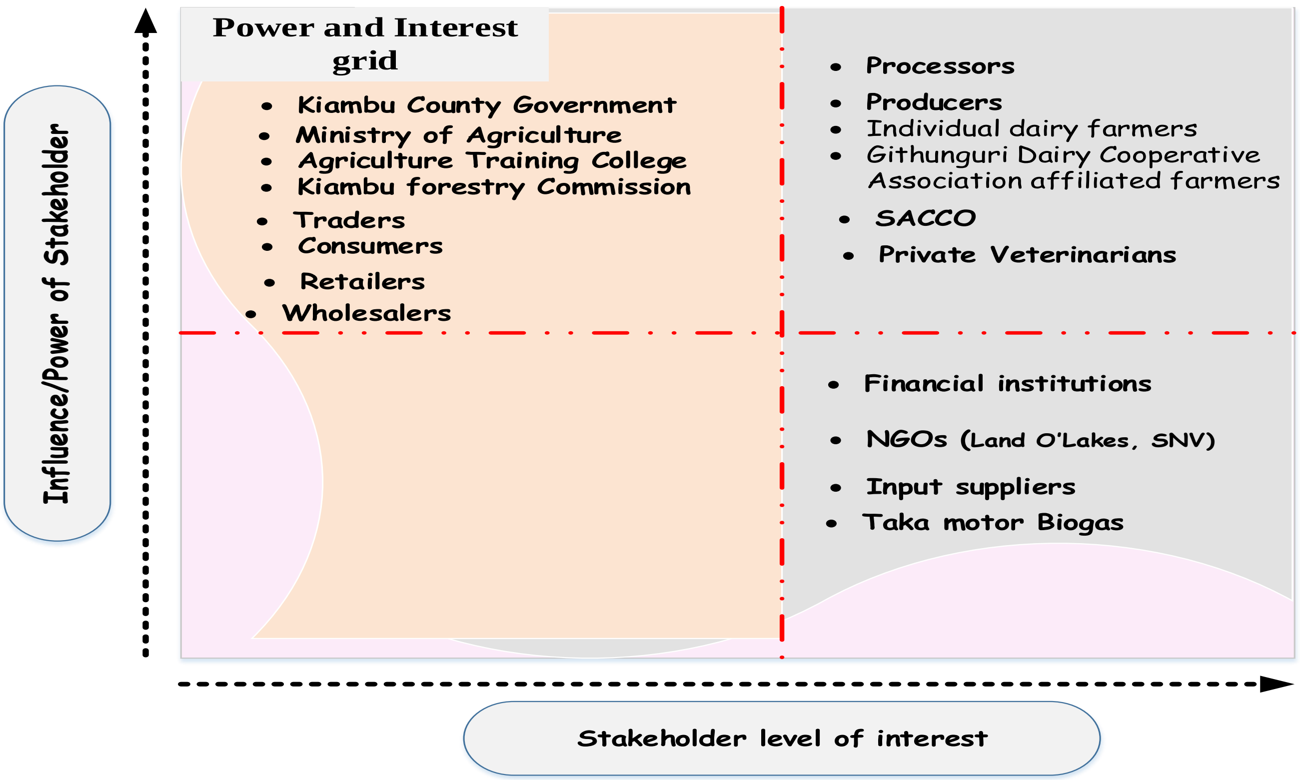
Company	**Services offered**
John Deere	Small scale fodder equipment / technologies
Agri-Quest and KALRO	Agronomic services and quality assurance to hay producers
Kenya Seed Company	Supply various fodder varieties
Insurance Company	Insurance of fodder to buffer against climate risks
Rift Valley Hay Growers Association	Working with Labs to develop quality standards for certification and lobbies the government through the Ministry of Agriculture for concessions on inputs, including fertilizer

2.22 Stakeholder analysis

For introduction of climate smart agriculture practices, we considered analyzing the stakeholders and the through the power and influence grid and the welfare triangle.

2.22.1 Power and influence grid

Figure 42 : Power and influence grid



The NGOs are concerned with poverty alleviation and increasing fodder security at household level whilst financial institutions (Equity), Takamoto biogas and input suppliers are interested in making money from the farmers. These players need to be considered in the fodder value chain and limited smartness.

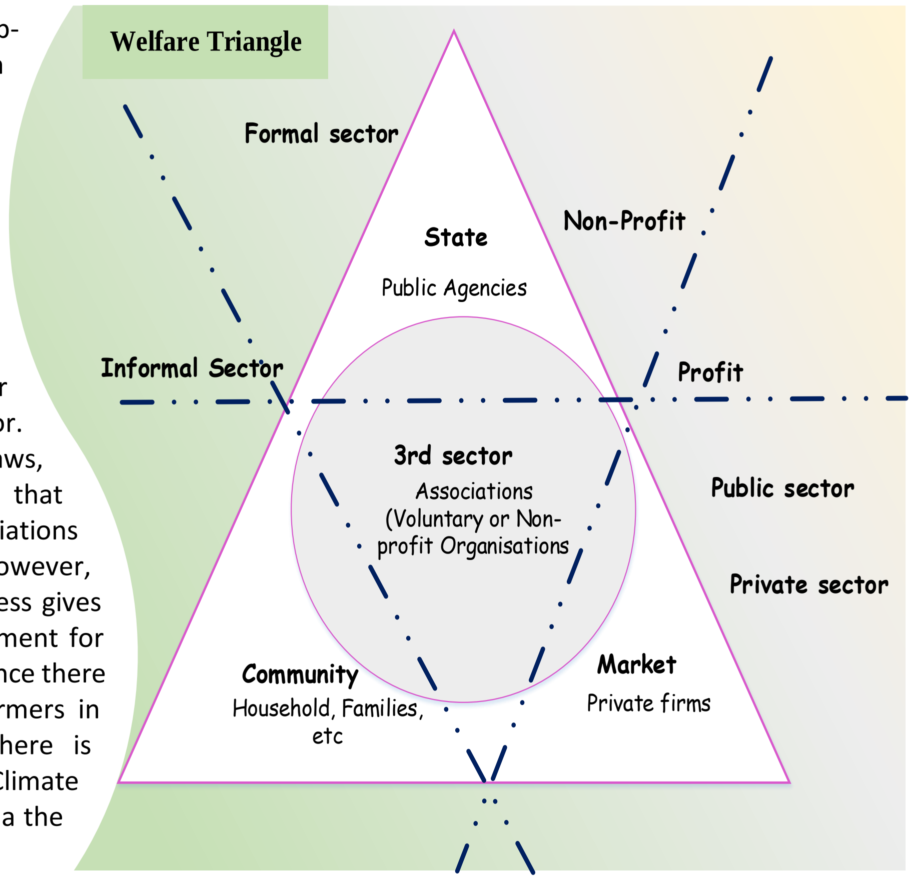
Consumer preference determines the packaging quantities and quality, product traceability, intrinsic and extrinsic product qualities. This is cascaded down to GDFC, retailers and wholesalers who the determines what they want from their suppliers (traders and feed production farmers). This makes them chain influencers and their needs ought to be met. Kiambu county government, Ministry of agriculture and training colleges are incorporated in this category.

The main value chain actors are the GDFC (composed of producers and processing capacity), SACO (financial institution) and private players who offer untiring support to needy farmers. GFDC produce the product and make it constantly available on the market in required quantities and packages. In addition to that, they are the custodian of their own constitution, making polices that promotes feed security to all households. It promotes entrepreneurship and levels the dairy value chain for all stakeholders.

2.22.2 Welfare triangle

This tool justifies the availability of space for adoption of new Climate Smart technologies in feed value chain by the most influential sector as shown on fig 43.

Figure 43:Welfare triangle



Currently Dairy Associations in Kiambu sub-county control the market due to high dependency of communities on dairy production. Associations organize farmers into groups and control them via stipulated legislations and statutory instruments. The private firms are hinged on performance of the associations as their businesses are biased towards dairy production. Therefore, the Government has a smaller share comparing with the private sector. Through the legislation, policies and by-laws, it controls some of the transactions that transpire in the market, but Farmer Associations regulations are more binding. However, Government reluctant approach to business gives Farmer associations a conducive environment for business. The third sector is Very large, hence there is space for available NGOs to assist farmers in making them Climate Smart. Hence there is enough room for new technologies and Climate Smart interventions to be implemented via the current farmer association models.

2.23 swot

Table 21:SWOT Analysis

	Strength	Weakness	Opportunities	Threats
Economic robustness	• Large population of dairy animals with good quality dairy breeds • Growing demand for quality feed which translates to quality milk production	• Insufficient supply of quality feed supply • Low overall value addition to feed • Low productivity due to reduced plot sizes • No variety on feed, its napier • High cost of feed conservation technology • Fragmentation of the feed value chain and low supplier loyalty	• Growing on farm fodder production and conservation • Increased demand for quality services (quality seeds) • Entry of young farmers willing to improve feed value chain for profitable dairy sector • Provision of embedded services by dairy cooperatives to reduce variable costs and increase farmer's revenue	• Poor road infrastructure • High cost of electric power • Small plot sizes • Feed quality concerns (aflatoxins, nutritive value)
Environmental robustness	• Favorable agro climatic conditions • Integrated farming systems ensuring use of manure and nutrient recycling	• Limited attention to reduction of greenhouse gases • Limited awareness about environmental impacts of feed production and conservation	• Promote green energy production • Increase support for appropriate climate change mitigation actions	• Loss of vigor of Kakamega1 and 2 in productivity • Environmental degradation and climate change impacts
Social robustness	• Tradition of ploughing one type of feed • Major source of dairy daily ration • Community development through farmer groups and cooperatives	• Increased rural urban migration • Low attraction for youth due to poor access to production factors	• Employment creation along the feed value chain (transporters, traders)	• Poor quality feed threatens animal health and milk productivity

These results are an indicator of a demand for CSA integration in agronomic practices in both sub-counties of Githunguri and Ruiru. GDFCS is better positioned to assist farmers achieve climate smartness.

Chapter 5: Discussion

5.1 Livelihoods and household demographics

Dairy production is notably the main source of livelihood in these two sub-counties. In Kenya, 80% of milk is produced by SHDF (MoALF, 2012). The involvement of youths is commendably sensational. Most farmers are accommodating their children (youths) on the same plots, with Ruiru having a higher percentage of youths in dairy production. This reflects the need for sustainable use of available resources for future generations. In some sub-counties e.g. Gishu, more than 61% of the youths are unemployed (Sulo., 2012). Youths have the capacity to adopt new technologies and implement lasting solutions to the global crisis of climate change at a faster pace. However, there is need of encouraging more youths to be involved in dairy production. In addition to that, the farmers need to train their youths in dairy for continuation of the projects beyond their generation. This will ensure integration of sustainable climate smart agricultural practices with the future in sight as youths take responsibility for lasting solutions. Farmers in Kenya are also literate.

Figure 44: Gender in dairy farming

Interview with Mrs Magret Kamura (Route 6)

Gender imbalances exist in decision making in both sub-counties. Mrs Kamura, in fig 44, is one of the female farmers surviving solely on dairy production. There is need to educate the families on the importance of involvement of women in decision making. Women do daily dairy project routines more often than men hence its critical to integrate climate smart agriculture practices since they lighten the load for women. In most instances, women are providing family labour in most dairy projects. With specific reference to use of bio-gas instead of firewood, application of slurry compared to raw manure, using taped water from a bulk tank than fetching water from the river or well. Thus, climate smart agriculture has a critical role in gender imbalances. Also, GDFCS is paying farmers via SACOS for their milk deliveries.

In conclusion, SMDF in Kenya involves women and youths but there is need to integrate them in decision making. Literacy rate of farmers is also commendable.

5.2 Dairy unit production parameters

Breed – Pure breeds perform better in milk production than crosses with diluted genes hence, breed efficiency is one of the climate smart practices. 20% cross breeds in Ruiru contributes to overall low milk production thus, farmers need to improve on breeds and breeding. Ruiru farmers also need to embrace quality breeds and buy them from recommended breeders than buying cheap unproductive cows which increase GHG emissions. This can be possible through securing funds from financial institutions. 70% of milk in Kenya is produced from pure breeds (FAO., 2011) and in Githunguri 100% are pure breeds. This is impressive. When increasing milk production there is a reduction in the amount of GHG produced per Kg of milk produced hence its climate smart. A reduction in the number of animals is also necessary to reduce the amount of GHG emissions from unproductive animals. In addition to that, selling of young stock also increases plot revenue whilst reducing GHG emissions.

Therefore, integration of climate smart should be more intense in Githunguri where there is more livestock and high demand of feed and in Ruiru climate smart interventions need to have sound production parameters addressed for farmers to appreciate viability of the dairy sector.

In conclusion, milk production is low in Ruiru and the calving interval is also high in the same sub-county. There is need of climate smart dairy practises to be integrated.

Figure 45: Retail shop and hay bale prices

Wheat straw @ KES110 & Boma Rhodes @ KES 180	Animal feeds shop

Feeding – Due to feed shortages farmers are rationing feed provisions to animals and at times give excess amounts of unpalatable feed. Therefore, farmers need to embrace feeding strategies that are climate smart since feeding an optimum amount of feed effects the amount of nitrogen utilised and that latter found in manure. This eventually reduces N_2O an NH_4 emissions. So, farmers need to increase feed efficiency and therefore be climate smart. In times of feed stress, farmers give brewer's waste, pine apple pulp and poultry waste to supplement feed. Unfortunately, all these fees are not climate smart if used in excess. They reduce the quality of milk and produce an unfavourable odour in milk leading to milk rejections by the GDFCS. Hence farmers need an integration of climate smart practices in their feeding practices. Rift valley Growers Association is working on quality controls to be out on hay bales.

Farmers also need to have actual productivity of their fields and rations they make for animals. Most farmers are making approximates of amount harvested and amount of feed given to animals. There are some feed losses being incurred and teat should be addressed for a dairy plot to be climate smart.

Figure 46: One of GDFCS retail outlets

GDFCS is securing feed and other ingredients for its farmers as shown in fig 46.

Interview with GDFCS's stores personnel (Thabitha)	Interviewer appreciating GDFCS's dairy feed on sale

Calving interval -There are no significant differences in calving intervals between the two sub counties though in Ruiru its taking an average of 18 months calving interval. This is a problem with most SHDF in Kenya. Long calving intervals lead to reduced milk production and losses in probable dairy herd increases. Fertility is linked to feed quality also, hence farmers need to feed their animals to a commendable body condition score for proper cycling. The body condition of some dairy animals taking long to cycle in fig 47.Body condition is also influenced by quality and quantity of feed.

Figure 47:Body condition of dairy animals

Body condition score of 3 dairy animals from different plots

Milk production- There is significant difference in milk production between the two sub-counties. Githunguri farmers are producing more milk hence, there is need of dairy feed security for Ruiru farmers for them to increase milk production. In comparison with Olenguruone, farmers averaging 10 litre per cow, Githunguri is performing well. Implementation of climate smart agronomic practices will therefore ensure feed security. There is a positive correlation between feed (quality and quantity) and milk production (quality and quantity) hence, there is need for climate smart feed production to ensure feed security to available dairy projects without deterioration of the environment.

Antibiotic use – Keeping dairy animals healthy and fertile so that they produce more milk and a calf per year is and indicator of dairy project efficiency. Since farmers are challenged by mastitis, there is reduced milk production and increased medication costs in addition to a temporary ban to supply milk till the withdrawal period is over. Immune compromised animals have a reduced feed conversion efficiency leading to increased GHG emissions. KMDP project done by SNV for happy cow was also focusing on reduction of milk rejections due to antibiotics (Rademaker., 2016). Hence this challenge affects most SHDF.

In cases of foot and mouth and rift valley fever, these viral diseases require antibiotics as secondary prophylactic treatment to prevent opportunistic infections. Excessive exposure to antibiotic leads to reduced recovery of animals after a bacterial infection leading to a prolonged reduced digestibility of feed and consequently increased greenhouse gas emissions. During dry cow therapy antibiotics are administered on every cow. In case of mastitis, farmers are preferring short acting antibiotics for treatment so that they can send their milk to the GDFC as soon as possible since it’s their main source of income for almost all farmers. This predisposes dairy animals to resistance to short acting drugs and consequently reduced digestibility of feed during period of compromised health condition and finally continued excessive greenhouse gas emission.

In both sub-counties, dairy animals are housed in stalls. This is a good climate smart practice as we can determine the type of feed the animal feeds on and monitor them regularly. However, some animals in Githunguri are being grazed in the forestry area and this is predisposing the dairy animals to helminths and parasites leading to an increased use of anti-biotics. Antibiotic abuse is not climate smart as it may lead to antibiotic resistance. Therefore, interventions in climate smart dairy herd management is crucial in Githunguri.

Plot land size – The significance difference in plot sizes between the two Sub-counties means Ruiru farmers have to scramble for climate smart practices that ensure feed security for their dairy plots. This is to increase the longevity of both finite and infinite natural resources on plots and reduce GHG emissions. Thus, sustainable production is to be promoted on the small highly productive pieces of lands. In Kenya, most SHDF are producing on very small pieces of land (1 Acre).

Napier field size – For both sub-counties, the mean size of Napier field is 1.0 acre with a standard deviation of 1.6. Ruiru has smaller Napier fields averaging 0.5 acres due to its smaller average land sizes. Hence, most farmers have resorted to outsourcing fodder for their dairy animals. This is not economical at small scale but with integration of climate smart agronomic practices, it is possible for them to be feed secure. In addition to that, they have to consider feed conservation especially silage that can be kept for long periods of time. Maize silage is another cheaper option that can be improvised with a little addition of irrigation. In Nakuru and Nyandarua, farmers outsource feed for their dairy animals. The average farm sizes of the smallholders are 5 to 10 acres and herd size ranges from 5 to 20 cows, with total milk production not exceeding 20 kg per day (Rademaker., 2016). Hence, feed production on plot is a challenge for most SHDF.

Plot rentals - Dairy animals that feed in the forestry area are predisposed to diseases and this increases antibiotic use. Hence, CSA practices that reduce exposure of dairy animals to parasites and pathogens is commendable. Rented plots can be effective if climate smart practices are implemented hence sustainably increasing yield for the dairy unit. However, land ownership reduces the level of motivation to invest in climate smart practices since productivity is more important to allow for investment on own piece of land.

In conclusion, farmers are facing a challenge of feed scarcity due to small plots and fodder production land sizes. This has led to compromised and inconsistent milk production levels. Feed contributes much to productivity and cycling of a cow. Hence, poor feed quantity and quality leads to compromised ability to fight infections and high use of antibiotics, long calving intervals and inability to exploit genetic potential. Hence, GHG emissions are inevitable.

5.3 Feed value chain governance

The feed governance is both market and modular governance. Farmers in Githunguri have a modular governance system since the GDFCS secures feed for them and they get it from its retail outlets. The farmers have a binding contract with the cooperative for milk production value chain hence the benefits are emanating from there. The farmers in Ruiru have a market type of governance since they buy feed from anywhere depending on price being offered. GDFCS has a market type of governance since it secures feed from travelling traders upon negotiating for price and ascertaining the quality of feed they want. It is prudent that the cooperative deal with feed the same way it deals with milk. Transition of farmers from market to modular, especially those in Ruiru, is a way of securing feed for all farmers. For market governance, there is need of sustainable production of feed at household level and reduce buying of feed from unscrupulous retailers who are after profit and not value sustainable production that mitigates the daily climate challenges we are facing. This is a cost cutting measure for dairy variable costs. For modular governance system, the GDFC can introduce fodder that is climate smart, cheaper and affordable for farmers and train them on production and silage making processes

In conclusion, farmers in Ruiru have a market type of governance whilst those in Githunguri have a modular type of governance. Farmers in Ruiru, who are affiliated to GDFCS are not wholly benefitting from the modular governance system because their credit worthiness is insignificant to consider continuous credit worthiness. In addition, they are further from GDFCS outlets and their milk supply is less.

5.4 Cost price and profitability of fodder

From the gross margin above, maize is more profitable than Napier production. However, Napier is more nutritive than maize as shown in fig 22. Maize can be equally competitive in nutritive value if it is reinforced with legumes. 6 farmers highlighted that making Napier silage is a problem and it is associated with many losses. Hence it is best to use cut and carry system to avoid losses on a handful of Napier from the small piece of land.

It is good to note that, Napier is the farmer's favourite feed due to its many advantages. Its labour extensive, if cut it rejuvenates on its own, its suitable for the cut and carry system. Hence, it has more advantages than the optional maize production. However, intercropping maize with a legume crop is more profitable since it improves quakity of feed and soil quality at the same time. Maize can be grown 3 times a year and provide the required amounts of feed and its suitable for silage. Its advantageous to use maize as an alternative to napier for climate smartness and feed security. There are also short season varities of maize which makes it a crop of choice and crop rotation is feasible

Table 22:Maize and Napier silage nutritive values

	Napier	Maize
Crude protein	11.9	8.6
Non-detergent fibre	64.2	46
Acid detergent fibre	37.7	26
Cellulose	30.7	22

Source: (Masaki., 2004)

In conclusion, it is advisable to promote maize silage production since it is climate smart and reinforce maize with silver leaf during planting. This is climate smart and will ensure availability of nutrients to dairy animals. Napier silage can also be used upon intensive training to minimise losses.

Figure 48: Extension workers motorbikes

GDFCS's extension workers transport system

5.5 Trainings

The GDFC has 12 extension workers who are motorized (As shown in fig 48) to cover the whole Githunguri sub-county doing on plot visit assisting farmers. Unfortunately, they do not extend to Ruiru. GDFCS also offers 1 training per month per route (As shown in fig 49) hence Ruiru farmers affiliated to GDFCS have to visit the nearest training centre for them to receive training services. Ruiru farmers usually get trainings from private vet doctors but GDFC is a better trainer since they are accountable for trainings and offer other services like artificial insemination. GDFCs also conduct a formal training once a month with all dairy members of that particular route. Plot visit routines by extension workers are done on a daily basis and farmer's problems are attended to in haste. Extension workers write reports and have work plans that reflect on services rendered to farmers on a daily basis.

Figure 49: Monthly training

GDFCS route 1 monthly training (July)

Climate smart trainings need to be incorporated in almost all farmer trainings and the current training platforms can be used effectively to deliver the message. Ruiru farmers need organize themselves into a group for ease delivery of CSA best practices to them.

In conclusion, GDFCS is offering extension services to farmers including trainings, Artificial insemination, health, nutrition. However, their extension workers need training on climate smart agriculture.

5.6 Support services

Trainings are on going in both Gothunguri and Ruiru. Basically its the GDFCS and the private veterinarians offering extension services. In Ruiru, only members afiliated to the coopertive can attend and the rest depend on fellow farmers or private extension which is expensive for them. Most of the trainings The support services are offering information on dairy productivity more than sustanability of the dairy projects and environmental management. Therefore there is need to incoporate climate smart agricultural practises in daily routines and trainings. Figures areshown on table

5.7 Climate smart agriculture practices

Figure 50:Farmer preference on type of tree to grow

	Criteria for choosing the type of tree to plant						
	Period to maturity	Timber and firewood	Availability of seedlings	Tolerance to dry spells	Animal feed	Source of income	Friut orchad
Githunguri	6%	71%			17%	6%	
Ruiru		71%	8%	8%	8%	22%	8%

Agroforestry - Grevilia trees are highly prioritized due to their ability to be intercropped with Napier and other fodder crops without any negative impacts. It's a good intercropping tree since it does not hamper fodder production but enhances it through nitrogen fixation in addition to that, they also provide good quality timber and firewood. They are also climate smart die to their ability to fix nitrogen. As shown in fig 50, 71% of farmers planted trees for timber and firewood. Ony 17% and 8% for Githunguri and Ruiru sub-county SHDF considered animal feed.

Gum trees are a good carbon sink and contribute much to climate smart agriculture. However, their high demand for water has negative impacts on the natural resource. Thus, its best for farmers to consider Grevilia trees which are multipurpose for giving firewood, timber for construction, feed for livestock and immensely contribute to nitrogen cycle. Most of the farmers prioritized eucalyptus and Grevilia trees because they provide timber for their dairy projects and fire wood for fuel. This is shown in table 46.

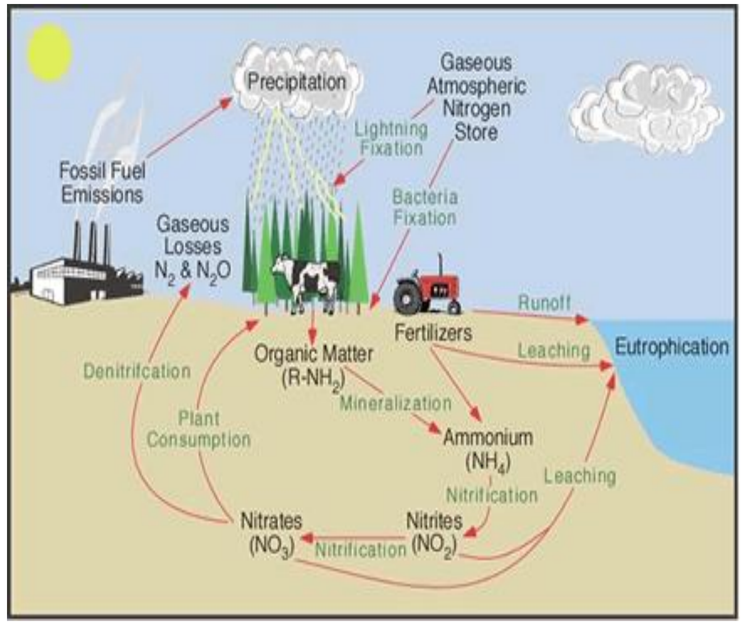
Tillage – Napier grass has no necessity for continuous cultivation since it forms a dense ground cover thus its climate smart. This reduces raindrop impaction and soil erosion in addition to conserving water. Most farmers, however, get their Napier from fellow farmers hence the plants are prone to stunting and reduced yields. Hence for climate smartness there is need for improved genetic Napier plants or hybrids to be used for initial panting. Sadly, all the farmers interviewed did not have exact amounts of Napier productivity but mere approximations of productivity.

Crop rotation – farmers are not rotating their fields, but they cut Napier and leave it to grow again on the same piece of land. There is need for integration of Napier with legumes to increase its nutritive value and also improve soil fertility by completing the nitrogen cycle.

Fodder conservation is limited. Most farmers are doing cut and carry method of fodder feeding. This lack of preserved fodder exposes farmers to feed insecurity especially when feed is scarce. In addition to that, as feed grows in the field it loses its peak nutritive qualities and become more fibrous due to lignification leading to less digestibility and increased GHG emission. This is because farmers consider bulkiness rather than feed quality due to feed challenges they face. Hence, cut and carry system is not climate smart if Napier is left to grow to 2m. Thus, fodder conservation needs to be promoted in both sub-counties increase the proportion of forage with low GHG emissions. On the other hand, silage making needs critical attention lest the process fail and result in fermentation.

Water conservation - Most farmers are conserving water as shown in the results. This is critical in supplementing water for irrigation hence improving climate smartness and fodder security. Unfortunately, none of the farmers is into irrigation independent of the availability of water at their homesteads. This is one untapped potential they have of growing fodder all year round and improve on climate smartness. Digging 1m^3 pits and putting stones is another way of harnessing water on plot hence increasing water table. This precious natural resource needs real conservation for smartness. Water harvesting is a climate smart practice that needs to be promoted also. Farmers are harvesting water, but they don't have sufficient fodder for their livestock. Farmers need to integrate sustainable irrigation on their plots and conserve fodder for use in periods of scarcity. They need to do silage which is both nutritious and long lasting. Hence integration of climate smart practices is necessary.

Figure 51:Nitrogen cycle



Source: (Adopted from Dairynz, 2013)

Fertiliser Usage, soil analysis and manure management – As shown in fig 51, utilization of nitrogen in manure and reducing nitrogen in faeces and urine through provision of quality feed is critical in achieving GHG mitigation.

Most farmers are putting manure ad_libitum in the fields. Since plants need different amounts of NPK at different stages, excess supply of manure leads to leaching of excess nutrients leading to eutrophication of rivers and water bodies. This results in suffocation of oxygen in water bodies and consequent aquatic ecosystem disturbance.

In some instances, manure is pushed out of the kraal and less than 60% is collected leading to leaching of nutrients into the soil. Application of manure is thus not generous as a stream of manure is made which goes to the field. However, manure usage should be increased for energy generation i.e biogas

Figure 52:Manure storage

Manure management

On fig 52 is a picture of one of the very few famers covering manure to reduce air exchange over the surface of manure which promotes GHG emissions. Unfortunately, the gas cannot be wholly contained but it's a sound mitigation measure.

Soil – Besides the abundancy of manure, some farmers still add a little fertiliser to cereal crop production especially for top dressing. Little do they understand that slurry is equally nutritive for top dressing. Therefore there is need for trainings on climate smart agronomical practices to make farmers aware of the need for biogas which completes most of the needs in dairy fodder production.

Feed transportation – The cut and pest method of feeding livestock is not economical in energy saving especially when the rented plot is at a distance. Continues visits to the field lead to increased production of CO and CO_2. Hence, there is need to transport feed in a way that save energy. Climate smart ways include use of large trucks that carry at once and prepare silage for future use. Plus silage saves revisiting the field continuously. The transport used for ferrying feed from the fields is commendable. However, it could be more efficient if feed was being collected for silage making since more feed is collected at once. Hence promotion of silage making does not only provide quality feeds for the animals but also efficiently minimizes CO_2 emissions. Thus, this climate smart practice needs to be integrated in dairy projects.

In conclusion;

1. Manure is being produced in excess and the fodder fields are used as disposal sites for manure. This has led to eutrophication of rivers and lakes hence disturbing the aquatic ecosystem.
2. 78% and 80% of farmers from Githunguri and Ruiru respectively, said they are into agroforestry. On most plots indigenous trees have been replaced by these exotic trees. Hence farmers are climate smart in reducing CO_2 and having an effective carbon sink. However, eucalyptus has a negative impact on water.
3. There is no crop rotation due to small pieces of land. However, on those unrotated fields, farmers can plant legumes along with fodder crops.
4. Farmers are practising cut and carry method of feeding cattle. They let feed grow tall in the field since they value quantity over quality. This has led to GHG emissions since as the feed grows lignification intensifies and digestibility is reduced.
5. Water conservation is currently being practised.
6. Hence there is need of intensive climate smart agriculture trainings for both the farmers and the extension staff.
7. There is increased emissions in feed transportation. This can be reduced through sustainable fodder conservation techniques.
8.

5.8 Farmer strategies and climate change

Farmers have their strategies to cushion themselves from climatic feed challenge shocks. The strategies ranked in the results section are analysed in the table below showing their strength, weaknesses and probable climate smartness in accordance to farmer's FGD rankings. After ranking the dry period strategies to ensure feed security on plot, I then evaluated the ranked strategies considering the strength, weaknesses and climate smartness or each strategy. The results have been documented in table 21.

Table 23:Climate smartness of farmer's strategies

Strategy	Strength	Weakness	Climate smartness
Feed on conserved feed e.g. silage	Ensures feed security on plot	It's expensive for farmers	It ensures quality feed hence its climate smart
Feed on crop residue e.g., maize Stover	Very cheap for farmers	Crop residue not readily available	Digestibility is low hence increases GHG emissions
Buying feed from traders/ GDFCs e.g. Lucene hay	Ensures feed availability on plot	It's expensive for farmers	Quality is not certain hence digestibility leads to GHG emissions
Buying concentrates	Ensures a constant milk production trend and it's highly digestible	It's expensive for farmers	Its climate smart but does not promote circularity of nutrients
Harvesting grass from public land, river banks and neglected coffee plantations	Very cheap for farmers	Predisposes animals to tick borne infections and helminths	Quality of hay is compromised hence promoting excessive GHG emissions due to low digestibility
Grazing on the forestry area	Forestry commission charges are affordable	Dairy cattle are prone to mastitis, tick borne infections and helminths	Feed quality cannot be monitored hence GHG emissions may be increased

The above strategies are based on the following preferences on conserved fodder

Table 24: Farmer's perception and preference

Feed	Preference	Perception
Napier	High	Its readily available, requires less labour and its perennial
Green maize Stover	Low	It's not readily available and farmers prefer storing Stover for periods of feed scarcity
Dry maize Stover	Medium	It can be stored and used when feed is in short supply but it's less nutritive. Thus, it does not add value to milk productivity and quality of milk
Rhodes grass bales	High	They are considered the best, but the buying price makes farmers shy away from them.
Wheat bales	Low	They are not always readily available
Lucene bales	Low	They are not readily available, and they are costly for the farmers

From the table on seasonality of feed production, In December farmers have sufficient but in January feed is scarce. This shows the challenge of not preserving feed. Hence feed conservation is a climate smart agriculture practice that needs to be cascaded to all farmers.

Githunguri sub-county has two rainy seasons whilst Ruiru is a bit drier. The climatic conditions are favourable for growth of fodder for dairy animals. Unfortunately, farmers on a yearly basis dig their wells to get water because the water table is constantly decreasing though at a slow rate. Thus, climate smart practices that retain water are crucial to maintain or improve then water table. This can be done through harvesting water in pits during the rainy season rather than leaving water to run off with all soil nutrients.

Farmers prefer using maize Stover as an alternative feed compared to buying quality hay for increased productivity and reduced GHG emissions. However, their second-best priority increases GHG emissions due to less digestibility and low nutritive value. Therefore, integration of climate practices is inevitable in Githunguri and Ruiru sub-counites.

Figure 53: Maize stover

Maize stover

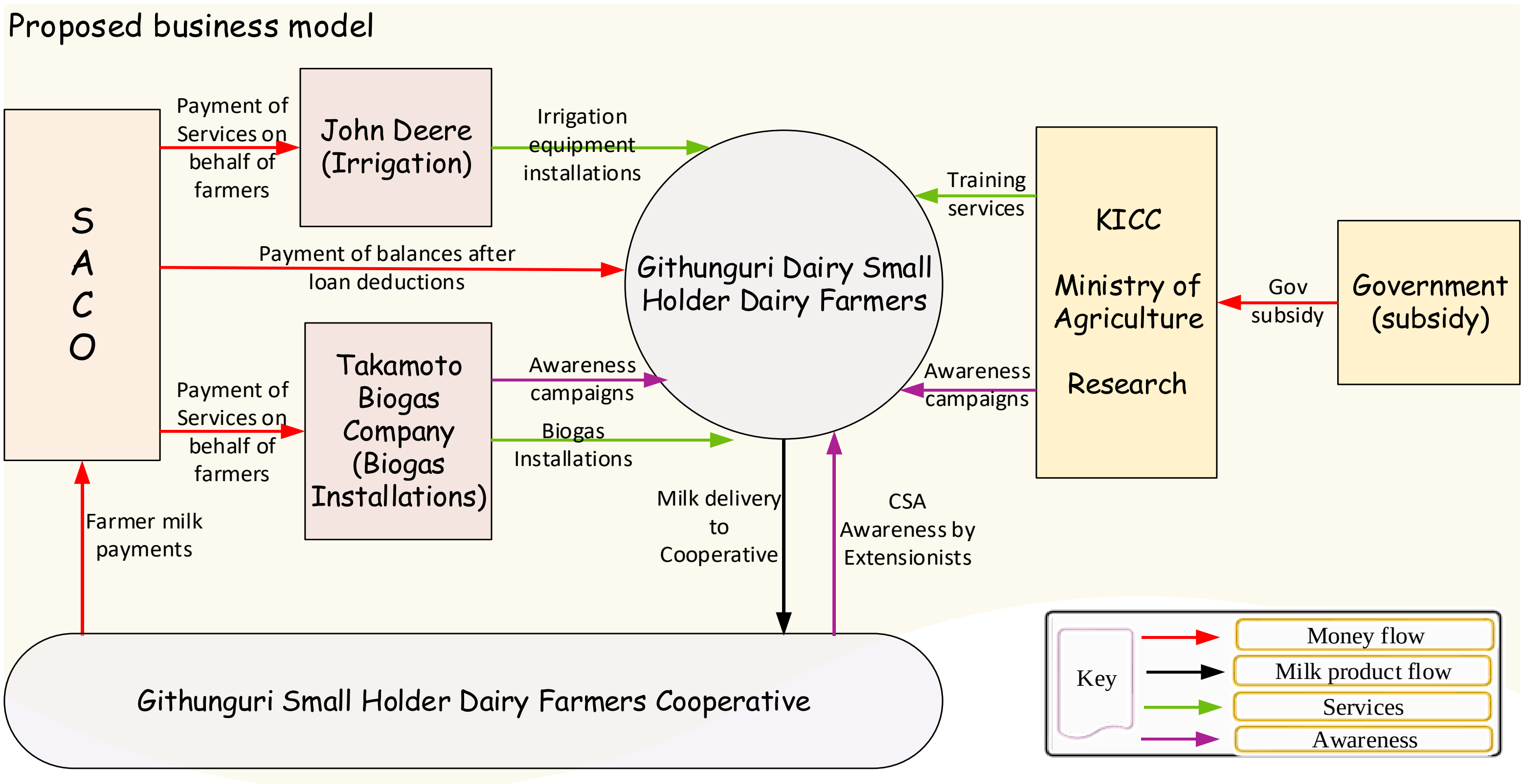
In conclusion, farmers have similar strategies to implement during different periods of feed scarcity as shown in fig 23. Napier grass is highly favoured due to its advantages as stated in table 24. Ruiru farmers are more prone to scarcity than Githunguri farmers. This is because Ruiru is drier. There is need of implementing climate smart feed practises that ensures feed availability with minimum GHG emissions.

5.9 Business model of introducing maize

The proposed business model for introduction of maize has a strong hinge on biogas installation as described below.

Biogas – Biogas production from manure can be one way to decrease greenhouse gas emission. Biogas production provides renewable fuel, allowing more efficient use of the nitrogen in manure and decrease greenhouse gas emissions from manure. Biogas supply energy that is needed for cutting hay using technology such as chaff cutters. Takamoto biogas company has chaff cutters that use biogas. Energy produced will also be used to pump water for both dairy units use and fodder irrigation. In addition to that, Biogas provides slurry that is nutritive for fodder planting and growth. Hence, fodder can be grown throughout the whole year and feed security is achieved with ease. There are short season varieties of maize that are critical for silage making and securing feed security at household level. Unfortunately, biogas adoption is still low.

Figure 54: Business model for stakeholder interactions



The farmers deliver milk to GDFCS and GDFCS pays them via a financial institution SACCO. The financial institution pays for biogas and irrigation to service providers and get its money by deductions from farmer milk payments. On the other hand, The Government subsidies their institutions to deliver the climate smart messages to the GDFCS members. GDFCS extension services department will be always on the ground assisting farmers, training CSA and solidifying linkages with service providers.

In conclusion, we will promote biogas installations for generation of sustainable energy for chuff cutters to cut feed, for sustainable energy for irrigation for maximum conservation and sustainable utilisation of water; and for reduction in over supply of manure to the field. Hence, with biogas its possible to switch types of feed grown.

The additional **remarks** column shows the analysis of on farm climate smartness

Table 25: Resource evaluation matrix

Dairy Resource		**Is there enough for the dairy unit?**	**Quality**	**Remarks**
LAND/NATURAL RESOURCES Fodder	Grasses	Yes	They use cut and carry system hence feed is fed fresh	**Small portions of napier grasses are available for dairy project**
	Fodder trees	No	They are leguminous hence fix nitrogen into the soil	**The few grevilia trees planted are intercropped in napier fields They are also on the periphery of the plot**
	Legumes	No		**There is an opportunity of incorporating legumes for climate smartness**
Agroforestry	Trees	Yes	Eucalyptus carbon sink was established 3 years ago	**Eucalyptus consume a lot of water hence impacts on climate smartness**
Portable water		Yes	Its borehole water pumped and stored in a tank for future use	**The water table keeps going down yearly**
River		Yes	It is an annual water source	**There is increased growth of algae and the water quantity is decreasing every year**
Soil		No	The land size is small for growth of enough feed	**Importation of concentrates reduces circularity and poor-quality feed increases greenhouse gas emissions**
LABOUR Farm workers		Yes	1 Permanent labour and 2 contract labourers	**Family labour is also available but it's not being costed**
CAPITAL Dairy cattle	Holstein Frisian	Yes	Averages 20 litres per animal	**The performance of the animals is climate smart**
	Aryshire	No		**A combination of two dairy breeds in the same unit is commendable**
Dairy Equipment	Chaff cutter	Yes	Its an electric 3 blade chaff cutter	**Chaff cutters that use biogas are also available**
	Milking machine	No		**This is an essential technology for clean milk**
Other livestock species	Goats	Yes	They are kept under intensive production system hence promoting climate smartness	**There is ease collection of manure and provision of quality feed to the ruminants**
	Chicken	Yes	A 7,000-broiler unit is functional	**Poultry manure is critical for top dressing hence positively impacting on CSA**
Farm structures		Yes	There are homestead, dairy unit and storage facilities	**The storage facilities**
Biogas	Floating drum	Yes	Its strategically positioned and powers both the dairy unit and homestead	**It is simple enough for the farmer to do minor repairs on her/his own**
	Fixed dome shaped	No		**It's not necessary to have 2 sets of different biogas types**

5.10 THE 5 CORE CAPABILITIES

I have used the 5 Cs due to its critical description for planning, monitoring and evaluation of capacity and its results of capacity development processes. GDFC has a sound Dairy and feed value chain which requires integration of climate smart practices for balancing efficient increase in quality feed production and climate change. Thus, it is critical to assess the GDFC institutional capacity in relation to its internal processes and actors in the value chain.

The capabilities were scored and listed in table 25.

Table 26: the 5Cs

5Cs	**Score**
Capability to act and commit	4.5
Capability to deliver on development objectives	4
Capability to relate to external stakeholders	3.8
Capability to adapt and self-renew	4.5
Capability to achieve coherence	4.4
Average	**4.3**

5.10.1 The Capability to Act and commit

Current strategic documents and work plans show GDFC commitment to ensure a sound fodder value chain and ensure feed security at farm level. The GDFC currently acquire feed for the farmers and sell it at a subsidized amount to cooperative members. They have enrolled AGRI company for a fodder project to start soon. In addition to that, a portion of Cooperative funds goes to extension for enhancing quality product (milk) production. Hence their extension workers are motorized and are equipped with necessary equipment and knowledge to assist farmers. This shows the dedication of GDFC to perform par excellence.

5.10.2 The Capability to generate development results

The extension workers have a laboratory for analysis of farmers milk queries and meetings daily. They also have access to internet and they update their trainings methodologies in accordance to farmer needs and current researches. This increases service delivery and efficiency. The GDFC has well-built infrastructure for milk collection and cooling centres for delivery of quality milk. However, climate smart feed production still a gap in their extension service. They are focusing on increasing production at the expense of the environment. The workers are continuously monitored, and the reporting system is intact to allow for monitoring and evaluation of individual performance.

5.10.3 The Capability to relate

GDFC works with all partners involved in dairy feed value chain in Githunguri. It has clear objectives that it follows in all its operations. It also participates in (inter) national networks in dairy value chain but to a lesser extend on climate smart agriculture. The cooperative engages fodder growers and distributors to facilitate ease availability of quality hay to the farmers. On the contrary, the GDFC is inward looking to the extend of not delivering quality service to farmers on the periphery of their boundaries e.g Ruiru small scale dairy farmers.

5.10.4 The Capability to adapt and self-renew

The GDFC is led by vibrant leaders who are hardworking and they engage stakeholders on all relevant matters. However, the cooperative is localized to Githunguri hence any intervention that requires much interference with outside stakeholders is met with resistance. Communication and dissemination of information is commendably sensational. Monitoring and evaluation is done continuously. They hold an annual general meeting once every year. They have a training session once every month per each route. Meaning farmers meet at least once a month and are refunded transport and provided with food. 100% of extension workers are in their youthful age and they deliver their mandate with swiftness. Thus, the GDFC capacity to meet quality service delivery demand is high.

5.10.5 The Capability to achieve coherence

The GDFCS has high potential and capacity to achieve coherence. Its documents; aim, vision, mission, work plan, are logically crafted. Implementation is their major strength that has kept them on the rise. The extension workers have laid out work ethics and deliverables that they account for daily. Staff are well informed as they can draft their own work plans in accordance to the Job description and key deliverables. Extensionists are more focused on their goals, work plans, monthly and yearly targets. Management uses top to bottom information delivery approach whist incorporating suggestions from farmers and extension reports. Systems and mechanisms for sound budget use are available and are followed with due diligence, and reports are constantly availed to the farmers for progress checks and transparency. Hence availability of enough and efficient resources enhances service delivery, staff performance and mainstreaming value chain feed approach.

Conclusion. We can safely conclude that GDFCS has the capacity to deliver on integration of climate smart practices to both Githunguri and Ruiru farmers. The extension workers are mobile, the management staff is qualified for their jobs and actively involved in the prosperity of the cooperative. They conduct trainings once every month and do daily plot visits to farmers and respond quickly to farmer's concerns. Despite all this, they also need to consider their short comings for efficient introduction of climate smart practices. They need to start looking out-side Githunguri and assist Ruiru farmers. Climate change is not selective of areas and more to those that are not integrating climate smart practices but rather it affects everyone on the planet. Thus, assisting Ruiru farmers will help us approach climate smart agriculture holistically. The cooperative trains its members only and that's a hindering factor to climate smart practice integration. Also, GDFCS staff (both management and extension workers) need trainings in CSA.

Chapter 6: Conclusion

6.1 Livelihoods and household demographics

1. In conclusion, SMDF in Kenya involves women and youths but there is need to integrate them in decision making. Most household labour is offered by women in both sub-counties hence, gender awareness campaigns are critical. Also, commendable is the youth involvement in decision-making in some households. Literacy rate of farmers is also commendable, making dissemination of climate smart messages by pamphlets and other media sources possible.
2. In conclusion, milk production is low in Ruiru averaging 11.3 litres, and Githunguri averaging 20.3 litres. The calving interval is also high in the same sub-county. There is need of climate smart dairy practises that promote fer#tility and cycling of cows to be integrated.
3. We conclude that, farmers are facing a challenge of feed scarcity due to small plots and fodder production land sizes. This has led to compromised and inconsistent milk production levels. Feed contributes much to productivity and cycling of a cow. Hence, poor feed quantity and quality leads to compromised ability to fight infections and high use of antibiotics, long calving intervals and inability to exploit genetic potential. Consequently, GHG emissions are inevitable.
4. In conclusion, GDFCS is offering extension services to farmers including trainings, Artificial insemination, health, nutrition. However, their extension workers need training on climate smart agriculture. It is also making linkages for the farmers to finance through milk payments via SACCOS.

6.2 Governance characteristics

1. In conclusion, farmers in Ruiru have a market type of governance whilst those in Githunguri have a modular type of governance. Farmers in Ruiru, who are affiliated to GDFCS are not wholly benefitting from the modular governance system because their credit worthiness is insignificant to consider continuous credit worthiness. In addition, they are further from GDFCS outlets and their milk supply is less.

6.3 Cost price and profitability of fodder

1. In conclusion, it is advisable to promote maize silage production since it is climate smart and reinforce maize with siratro during planting. This is climate smart and will ensure availability of nutrients to dairy animals. Napier silage can also be used upon intensive training to minimise losses.

6.4 Trainings

In conclusion, GDFCS is offering extension services to farmers including trainings, Artificial insemination, health, nutrition. However, their extension workers need training on climate smart agriculture. Only Ruiru farmers affiliated to GDFCS receive trainings. Private trainings are expensive for SHDF.

6.5 Climate smart agriculture practises

In conclusion;

1. Manure is being produced in excess and the fodder fields are used as disposal sites for manure. This has led to eutrophication of rivers and lakes hence disturbing the aquatic ecosystem.
2. 78% and 80% of farmers from Githunguri and Ruiru respectively, said they are into agroforestry. On most plots indigenous trees have been replaced by these exotic trees. Hence farmers are climate smart in reducing CO_2 and having an effective carbon sink. However, eucalyptus has a negative impact on water.
3. There is no crop rotation due to small pieces of land. However, on those unrotated fields, farmers can plant legumes along with fodder crops.

4. Farmers are practising cut and carry method of feeding cattle. They let feed grow tall in the field since they value quantity over quality. This has led to GHG emissions since as the feed grows lignification intensifies and digestibility is reduced.
5. Water conservation is currently being practised.
6. Hence there is need of intensive climate smart agriculture trainings for both the farmers and the extension staff.

6.6 Seasonality of farm feed production

1. In conclusion, farmers have similar strategies to implement during different periods of feed scarcity as shown in fig 23. Napier grass is highly favoured due to its advantages as stated in table 24. Ruiru farmers are more prone to scarcity than Githunguri farmers. This is because Ruiru is drier. There is need of implementing climate smart feed practises that ensures feed availability with minimum GHG emissions.

6.7 Proposed business model for introducing maize

1. In conclusion, we will promote biogas installations for generation of sustainable energy for chuff cutters to cut feed, for sustainable energy for irrigation for maximum conservation and sustainable utilisation of water; and for reduction in over supply of manure to the field. Hence, with biogas its possible to switch types of feed grown.

6.8 Potential of GDFCS to introduce new CSA practises

1. We can safely conclude that GDFCS has the capacity to deliver on integration of climate smart practices to both Githunguri and Ruiru farmers. The extension workers are mobile, the management staff is qualified for their jobs and actively involved in the prosperity of the cooperative. They conduct trainings once every month and do daily plot visits to farmers and respond quickly to farmer’s concerns. Despite all this, they also need to consider their short comings for efficient introduction of climate smart practices. They need to start looking out-side Githunguri and assist Ruiru farmers. Climate change is not selective of areas and more to those that are not integrating climate smart practices but rather it affects everyone on the planet. Thus, assisting Ruiru farmers will help us approach climate smart agriculture holistically. The cooperative trains its members only and that’s a hindering factor to climate smart practice integration. Also, GDFCS staff (both management and extension workers) need trainings in CSA.

Chapter 7: Recommendations:

7.1 Livelihoods and household demographics

1. Promote women and youth empowerment through trainings and literature e.g. brochures
2. Conduct awareness campaigns , taking advantage of indigenous knowledge for knowledge exchanges and communication purposes

7.2 Dairy unit production parameters

1. Promote breed improvement programs in Both sub-counties. This can be done through use of Artificial insemination, selling unproductive cows and replacing with Holstein or Aryshire. In addition to that, Climate smart productivity needs to be promoted including practises like proper heat detection, feeding quality feed in nutritive proportion and maintenance of cows in good health. Reduction of unproductive animals like steers is also promoted together with preservation of high producing cows.
2. Facilitate mechanisms that support fodder production and security at farm level, disease control, water management

7.3 Feed governance

1. I suggest that GDFCS consider and value feed supply as much as milk supply and upgrade the governance from market to modular type of governance.
2. I suggest that the Ruiru farmers be encouraged to use GDFC for their milk supply for them to benefit the subsidised quality feeds.
3. Also, Identifying entry points for private sector investments

7.4 Cost price and profitability of fodder

1. I support the idea by the cooperative to introduce a new business model for napier replacement by maize
2. I suggest legume reinforcement in all animal feed pasture lands.
3. I propose more focus on fodder projects that are pro-mitigation and adaptation to climate change whilst securing feed availability for small holder dairy farmers

7.5 Potential to introduce CSA practises

1. GDFCS should consider assisting farmers in Ruiru.
2. I suggest that farmers in Ruiru organise themselves and form Ruiru association affiliated to GDFCS

7.6 Climate smart agriculture practises

1. Conduct awareness and advocacy campaigns, basing on sound evidence base, so that impacts and consequences of climate change on feed value chain and dairy production are understood. Through;
   - Integration of climate smart practices in monthly trainings and on plot advisory services to support adaptation and mitigation of climate smart practices
   - Informing fodder value chain players on the critical importance of mitigating climate change
   - Implementation of research-based climate change evidence in fodder and dairy production systems
   - Informing the cooperative decision makers on topics related to climate change and long-term benefits of Climate Smart practices

2. Promote grevilia trees growth. In addition to that, GDFCS is to provide trainings to the farmers on al climate smart agriculture practises.
3. Promote use of hybrid splits for planting and constant replacement of Napier field every 4 years or when productivity is lowering.
4. Improve the quality of nutrients by integrating with legumes.

7.7 Seasonality of farm feed production

1. I recommend utilisation of the two rainy seasons for feed production and irrigation for the third dry season
2. The cooperative should continue subsidising feed for the farmers
3. Implementation of innovations and solutions derived from climate change related research, including technological advancements. Through;
4. Incorporation of private sector in securing lasting Climate Smart feed production solutions that promote very low carbon emissions e.g biogas and bio-gas powered chaff cutters
5.

7.8 Business model for introducing maize

1. I propose the business model in fig 53 since it facilitates introduction of another type of feed that suits the prevailing farmer feed challenges.

7.9 Potential of GDFCS to introduce new CSA practises

1. Participate in Kiyambu County and National platforms and have strategic partnerships on Climate Smart Agriculture. Through;

- Interaction with other stakeholders to provide consolidated approach to mitigating effects of climate change on feed value chain
- Creating a platform for stakeholder sensitization and also for learning and communications amongst relevant stakeholders in feed and dairy value chain

Chapter 8: Reference

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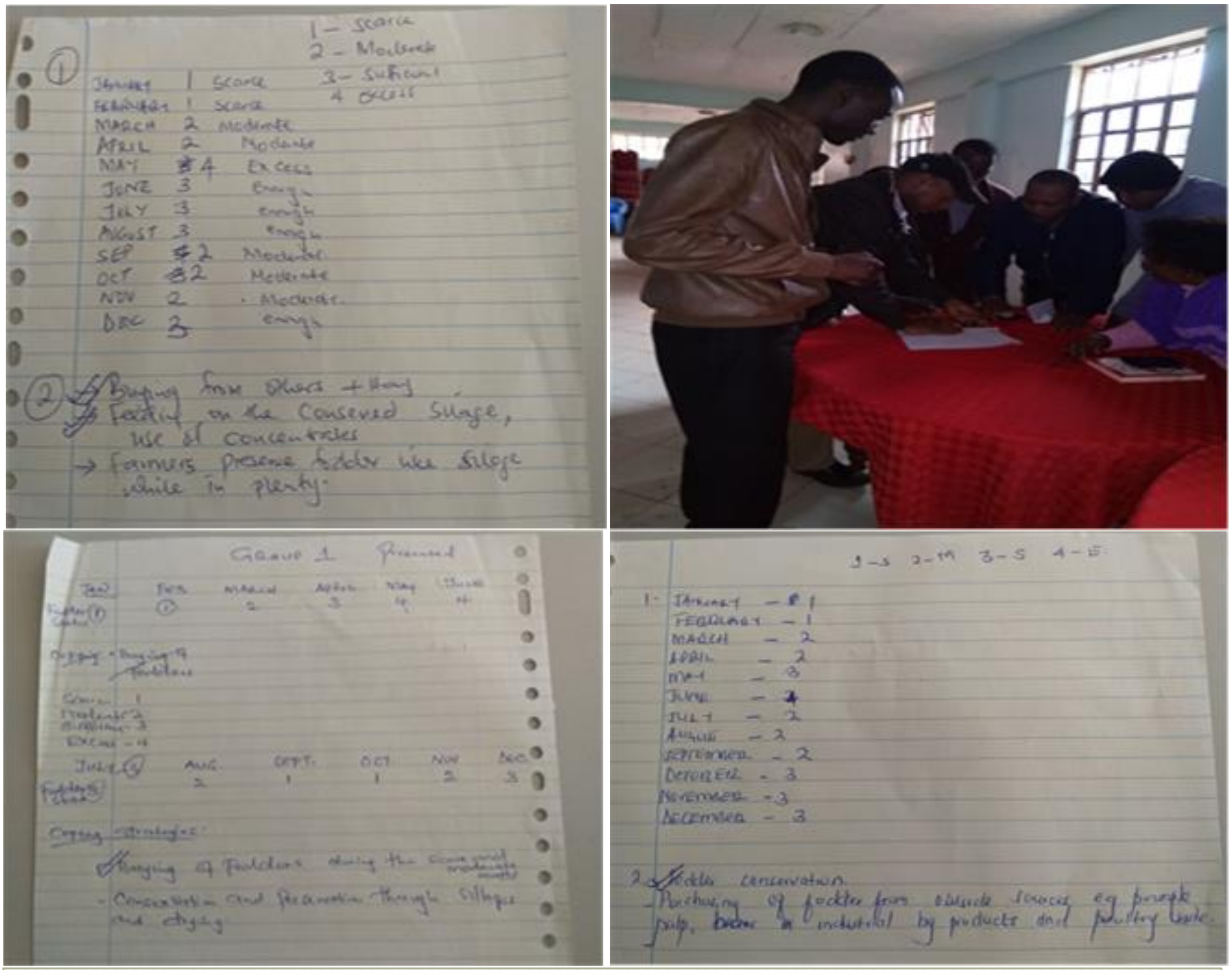
Chapter 9: Annex

Annex 1: Focus group discussion



Sample of focus group discussions contributions

Annex 2: Household size

Independent Samples Test: **Household size**										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
What is your household size?	Equal variances assumed	.097	.757	-.146	40	.884	-.089	.608	-1.317	1.139
	Equal variances not assumed			-.140	25.626	.890	-.089	.634	-1.393	1.216

Annex 3: Plot labour availability

Independent Samples Test: **Plot Labour availability**										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
What is the number of workers?	Equal variances assumed	1.123	.296	3.175	40	.003	1.296	.408	.471	2.121
	Equal variances not assumed			3.603	39.226	.001	1.296	.360	.569	2.024

Annex 4: Family labour

Independent Samples Test: **Family labour**										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
How many family members work on the farm?	Equal variances assumed	.042	.838	.086	40	.932	.037	.431	-.834	.908
	Equal variances not assumed			.086	28.849	.932	.037	.432	-.847	.921

Annex 5: Number of dairy animals

Independent Samples Test: **Number of dairy animals**										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
What is the number of dairy animals?	Equal variances assumed	9.337	.004	2.997	40	.005	9.607	3.206	3.128	16.087
	Equal variances not assumed			3.889	31.726	.000	9.607	2.470	4.574	14.641

Annex 6: Number of milking cows

Independent Samples Test: **No of milking cows**										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
How many milking cows do you have?	Equal variances assumed	10.346	.003	3.519	40	.001	4.541	1.290	1.933	7.149
	Equal variances not assumed			4.601	30.657	.000	4.541	.987	2.527	6.555

Annex 7: Calving interval

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
What is the calving interval?	Equal variances assumed	8.612	.006	-4.383	40	.000	-3.319	.757	-4.849	-1.788
	Equal variances not assumed			-3.642	17.695	.002	-3.319	.911	-5.235	-1.402

Annex 8: Milk production

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
What is the average milk production?	Equal variances assumed	11.964	.001	2.929	40	.006	72.0296	24.5935	22.3243	121.7350
	Equal variances not assumed			3.844	30.101	.001	72.0296	18.7390	33.7648	110.2945

Annex 9: Land size

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
How big is the land size?	Equal variances assumed	12.606	.001	4.331	40	.000	1.8703704	.4318845	.9974993	2.7432414
	Equal variances not assumed			5.711	29.387	.000	1.8703704	.3274883	1.2009646	2.5397762

Annex 10: Napier field

Independent Samples Test

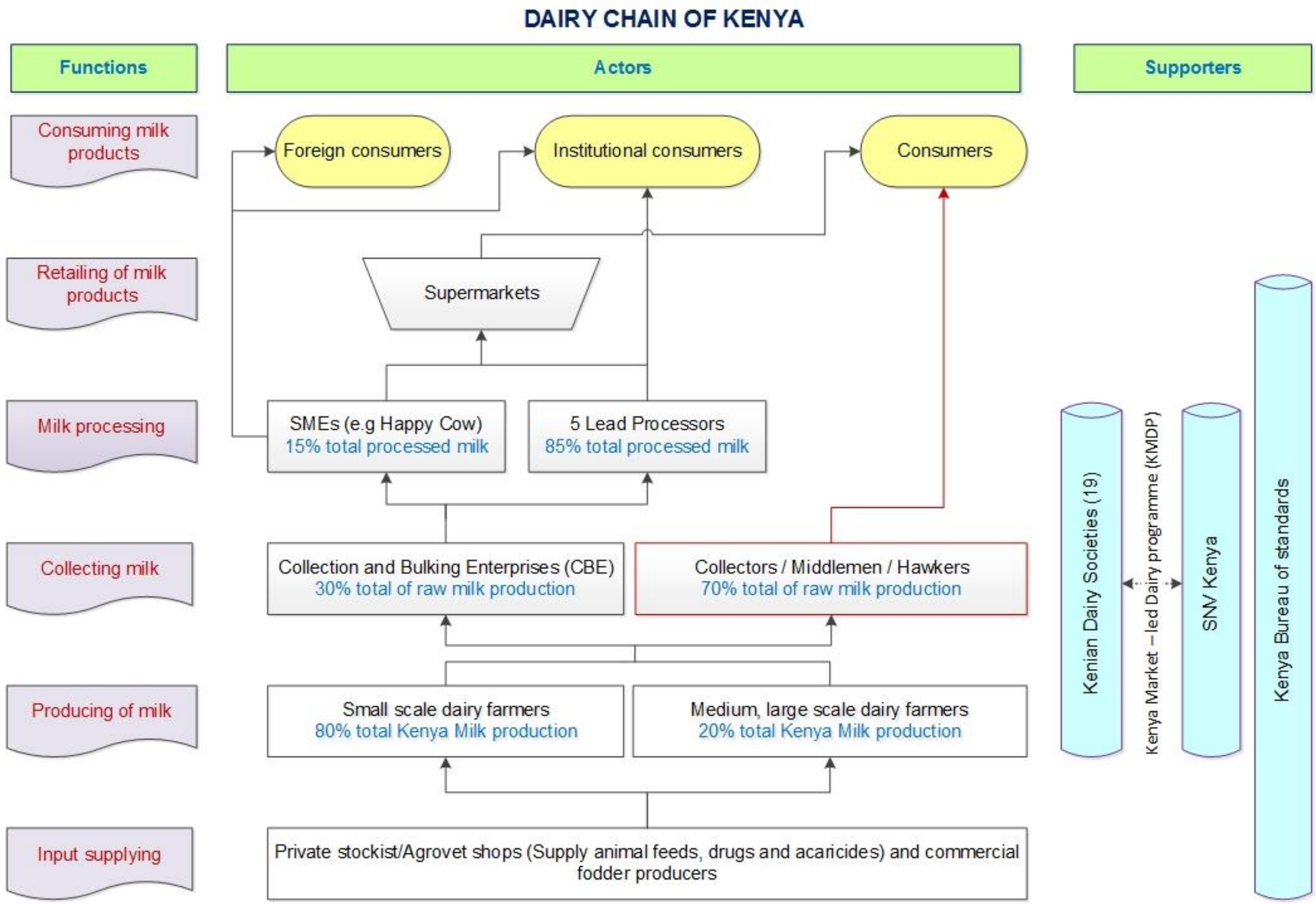
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
How big is the napier field?	Equal variances assumed	2.203	.146	1.659	40	.105	.8135185	.4903628	-.1775418	1.8045788
	Equal variances not assumed			2.179	29.980	.037	.8135185	.3733245	.0510667	1.5759704

Annex 11:Main source of income

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
What is the main source of income?	Equal variances assumed	2.151	.150	-.548	40	.587	-.185	.338	-.868	.498
	Equal variances not assumed			-.528	26.121	.602	-.185	.351	-.906	.535

Annex 12:Dairy value chain of Kenya



Annex 13: Maize budget

		Maize Budget		
Item	**Unit**	**No of units**	**Amount / unit**	**Total**
Maize Yield/ acre per harvest	50 kg Bags	42.00		38.00
Number of harvests/Yr	Harvests	3.00		3.00
Yield/ acre/ Year	50 kg Bags			114.00
Total A	**KES**	**114.00**	**800.00**	**91,200.00**
Maize Stalks yield / acre/ harvest	tonnes	4.00		4.00
Number of harvests/Yr		3.00		3.00
Price / tonne	KES	1 tonne	250.00	250.00
Total B	KES			**3,000.00**
Gross Output (Total A+B)	KES			**94,200.00**
Variabble Costs				
Planting material/ acre	KES	3.00	480.00	1,440.00
Number of plantings / Yr		3.00		3.00
Chemicals (Pesticides)		3 litre	500.00	1,500.00
Manure	KES	21.00	750.00	15,750.00
Total A				**18,690.00**
Planting and harvesting				
Hired labour (planting, weeding, manure, Harvesting)	KES/ LDs	12.00	400.00	4,800.00
Family labour	KES/ LDs			4,600.00
Packaging material	packs			1,800.00
Transport		5000	3	15,000.00
Total B	KES			**26,200.00**
Total C (Total A+B)				**44,890.00**
Gross margin	KES			**49,310.00**
Depreciation	KES			4,000.00
Interest	KES			6,720.00
Net Income	KES			**38,590.00**

Annex 14:Napier Budget

		Napier Budget		
Item	**Unit**	**No of Units**	**Amount/Unit**	**Total**
Yield/ acre per harvest	Tonnes	12.00		12.00
Number of harvests/Yr		3.00		3.00
Yield/ acre/ Year	Tonnes	12.00	3 harvests	36.00
Price / tonne	KES	1 tonne	1,400.00	1,400.00
Gross Output	KES			**50,400.00**
Variabble Costs				
Planting material/ acre	KES	1 tonne	2,500.00	2,500.00
Manure/ acre	tonnes	7.00	500.00	3,500.00
Total A				**6,000.00**
Harvesting and bailing				
Hired labour	LDs	20.00	400.00	8,000.00
Family labour	LDs		3,600.00	3,600.00
Total B	KES			**11,600.00**
Total C (Total A+B)				**17,600.00**
Gross margin	KES			**32,800.00**
Depreciation	KES			1,166.67
Interest	KES			2,400.00
Net Income	KES			**29,233.33**

i) Focus group discussion:

- Governance
  1. Which organizations contribute to the feed value chain?
  2. What are the relationships between these organizations?
  3. What are the interactions between traders, buyers and farmers in the feed value chain?
  4. Are there any contracts between farmers and value chain actors? If yes, kindly explain…….
  5. What are the required or stipulated standards of feed products in the feed value chain?
  6. What regulations and regulatory bodies govern or influence the feed value chain?
  7. How is the management of the producer/ farmer organization organized?
  8. What are their written or unwritten norms that influence their participation and competence on the market?
  9. What are the expectation from the public?
- CSA Practices
  1. What are the agronomic practices that you do in both feed and dairy production?
  2.
- Stakeholder analysis
  1. What are the relevant stakeholders in feed value chain?
  2. Which organizations influence the chain?
  3. Which organizations implement the legislation or are custodians or rules and regulations that govern the feed value chain?
  4. Which organizations benefit from the feed value chain?
  5. Which organizations play a significant role in solidifying the feed value chain?
  6. Which organizations benefit from an intact feed value chain?

ii) Key informant interviews:

- The 5 Cs
  1. What are the relationships or linkages with between GDFC and other stakeholders?
  2. To what extend is the GDFC flexible to shift to different situations and changing product trends?
  3. To what extend do they evaluate their learning and stimulate learning and exchange with others?
  4. Which activities of the GDFC are linked to their output and objectives?
  5. How do they disburse resources in line with their operating principles?
  6. How does the organization motivate its staff?/
  7. What contribution does the organization employees make towards the mission, vision and strategy of the organization?
  8. Ho does the organogram of the cooperative look like?
  9. What are the gender balances in the organization?

iii) Resource evaluation matrix:

1. What are the key dairy project resources that you have?
2. Are the resources enough for the dairy unit?
3. How did you acquire or set up the resources?
4. How do you manage the resources?
5. What is your resource sustainability plan?

Annex 15: Resource evaluation matrix

Dairy Resource		**Is there enough for the dairy unit?**	**Quality**
Portable water			
Fodder	Grasses		
	Fodder trees		
	Legumes		
Agroforestry	Trees		
Biogas	Floating drum		
	Fixed dome shaped		
Dairy cattle	Holstein Frisian		
	Aryshire		
Dairy Equipment	Chaff cutter		
	Milking machine		
Other livestock species	Goats		
	Chicken		
Farm structures			
Farm workers			

iv) Questionnaire:

Section A: Household information

Introduction: "My name is …………, and I am a student at Van Hall Larenstein University of Applied Science in Netherlands. I am working on a project analyzing the integration of Climate Smart Agriculture practices in Feed value chain in Githunguri. I am conducting the survey with 45 farmers in this area. I would want to conduct an interview and your participation and cooperation is greatly appreciated. All information you provide will be treated absolutely anonymously

1. FM No:_____Date:_________ Sub county_____________________ Ward ____________________
2. Route_____________________ Other____
3. What is the name of farmer (H/H)?____
4. Name of respondent____RSp___________________
5. What is the age of farmer?__________________
6. What is the size of the household____
7. Who is the main decision-maker regarding different farming activities?___________________
   ***decision maker:** 1=Father; 2=Spouse; 3= Son; 4= Daughter; 5=Farm worker; 6= Other ____
8. How many family members work only on the farm? _______ only off the farm? _______

9. Kindly share with us some information on these household members.

HH member	**Gender** *1=Male 2=Female*	**Age** *(years)*	**Highest education level***	**Marital status ****	**Primary occupation *****	**Main sources of income** ****		
HH/Resp						1.	2.	3.

*__Education level:__ 0=None 1=Adult education 2= Primary 3= Secondary 4=College 5= University 6=Other (specify) ___________________________________
**__Marital status:__ 1 = Married; 2= Single; 3 = Divorced; 4 = Widowed; 5 = Other (specify)____
***__Primary occupation:__ 1= Farming 2=Off farm
******Sources of income**: 1= selling milk 2= selling tea 3= selling seedlings 4= Seasonal farm laborer 5= occasional off farm jobs 6= Government job 7= Other (specify) ________

Section B: Land Ownership

10. What is the main type of ownership for the land you have?______________________________
    ****Ownership**: 1=Traditional/communal; 2=Freehold without title; 3= Freehold with title; 4= Leasehold/Rented in; 5= Other (specify)_________________________________
11. How big is the land?____
12. Do you currently rent more land for Dairy/ fodder production?____________________________
    Acreage____

Land use	Acreage
total	

*Indicate rented fields also with **"R"**
***conversion:** 1 ha= 2.47 Acres

Section C: Fodder production

13. Have you planted fodder on your farm currently? ___________ 1=Yes 0=No
14. If you have NOT planted fodder what are the reasons? *[rank: 1= most important to 3=least important]*
    ***Options:** 1=Small land size; 2=Lack of seeds/planting materials; 3=Lack of labor; 4=Cheap to buy; 5= Lack information on fodder types to plant; 6= Lack of money for establishment; 7=Other (specify)______
15. If YES, what types of improved fodders have you grown on your farm and their production levels?

Fodder types	**Growing** (1=Yes; 0=No)	**Where cultivated***	**Method of planting**	**Area cultivated** (acres)	**When established** (month & year)	**Sources of seed****	**Production level*****	**Harvesting stage**
Napier grass								
Maize								
Lucerne (Alfalfa)								
Dolichos lablab								
Other:___________								

***where cultivated:** 1= On plot, 2= Plot boundary, 3= Terrace bank, 4= Bush land,*
****seed sources:** 1= Neighbor, 2 = Own seed, 3 = Lead Farmer 4=Githunguri cooperative 5=Other(specify)______*
*****Production level:** 1=Poor, 2= Moderate, 3= High

16. How big is the land and cleared for fodder growing (Acres)?_________________________________
17. What determines the total area of the farm you put under improved fodder production? *[rank from 1= most important to 3=least important]* ______________________________________
    ***Options:** 1= Farm size; 2=Number of livestock; 3=Labour availability; 4= Amount of seed/planting material available; 5= Other (specify)________________________________
18. What is the quantity of fodder produced and use?

Land use (from above) for fodder	Quantity produced Kgs	Quantity utilized on the farm	Quantity sold kgs	Price per unit *(Ksh)*

19. What criteria are important to you when choosing the type of fodder to plant? *[rank from 1= most important to 3=least important]*

1.	2	3

1= High yielding; 2=Fast growth; 3= Animal produce more milk; 4=Disease/pest tolerant; 5= Easy to harvest and feed to animal; 6=Availability/cost of seed/planting material; 7=Advice from extension workers; 8= climate tolerant; 9=Other (specify)_______________________________

20. Have you planted any agroforestry trees on your farm currently? _______ 1=Yes 0=No

21. If NOT, why? _________________1= Lack of preferred seedlings; 2=High cost of seedlings; 3= Small land size; 4= Unreliable rainfall; 5= Other (specify) ____
22. If YES, what types of agroforestry trees have you grown on your farm and their production levels?

Agroforestry tree types	**Growing** (1=Yes; 0=No)	**Where cultivated***	**Number of trees**	**When established** (month & year)	**Sources of seedlings****	**Production level*****
Crevillia						
Calliandra calothyrsus						
Leucaena trichandra						
Sesbania sesban						
Other:						

***Area of cultivation:** *1= Plot land, 2= Plot boundary, 3= Terrace bank, 4= Bush land*
****Source of seedling:** *1= Neighbor, 2= Own nursery, 3= Githunguri cooperative, 4= Market,*
*****Production level:** *1=Poor, 2= Moderate, 3= High*

23. What criteria are important to you when choosing the type of trees to plant? *[rank from 1= most important to 3=least important]*

1.	2	3

1= Period to maturity; 2= Number of uses; 3=Availability of seedlings; 4= Tolerance to dry spells; 5=Other (specify) ___________________

24. What crop residues are used to supplement dairy feed?

Crop residue	Quantity	Value addition	Amount fed / cow
Herbs			
Maize			
Pine apple pulp			
Outsourced Hay / straw			
Breweries waste			
Poultry waste			
Concentrates – Dairy meal			
- other			
Agro industrial by-products			
French beans			
Other			

**Collect per year and multiply average by total No of farmers

25. What do you do with surplus fodder?______________________
1 Give to neighbors, 2 Sell to fellow farmers, 3 Make hay or silage, 4 Leave it on the farm
5 others____
26. What methods of fodder preservation are implemented?

Fodder	**Preservation**

27. What is the price of fodder in different months of the year?

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Napier												
Boma Rhodes												
Silage												

List common grasses sold

28. What is your usual means of feed transportation?_______________________

***Transport:** 1=Car; 2=Motor bike; 3=Bus/public transport; 4= Bicycle; 5=Walk; 6=Other____

29. Do you experience feed shortage?____
30. Rank the following feed copying strategies according to your preference?

Coping strategy	Rank	Time (Which months?)
Use of conserved feeds (hay, silage)		
Feeding crop residue (e.g. Maize stover)		
Off farm purchase of feeds (hay, maize stover)		
Purchase concentrates		
Harvesting of grass from public land (forests, river banks)		
Grazing on public land		

***ranking:** 1=mostly used, 6=least used

31. Which months have sufficient or deficit fodder for the dairy unit

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fodder status												

1 Excess, 2. Sufficient, 3. Moderate, 4. Scarce

Section D: Manure

32. Have you collected manure from your farm in the last 12 months?__***Options:** [1=Yes, 2=No]

33. What is the total amount of manure produced on the farm?__________________________________
34. What's the method of manure collection?____

***Manure collection:** 1= concrete floors, 2= Bucket collection, 3= Other_______________________

35. What do you do with livestock manure? *[rank from 1= most important to 3=least important]*

1= Used in food crop production; 2= Apply to fodder; 3= Use dry dung for fuel; 4= Use in biogas generation; 5= Use as construction material; 6= Sell to others; 7=Other (specify)

____

36. What is the total amount of manure and/or fertilizer used?

Land use (from above)	Fertilizer used (Kgs)	Manure used (kgs)

37. If YES, how do you manage the manure produced by your livestock? ___________________

***choose one option:** 1= Cover in a pit; 2= Collect under shade; 3= Collect uncovered in the open; 4=Compost it; 5= Discard in surrounding area; 6= Add ash; 7= Other ________________

38. If you do NOT use manure for fodder production, what is the main barrier? *[Select one]*_________
1= Lack of labor to collect or apply it; 2=Small manure quantities; 3= No livestock owned 4= Other specify)_____________________________________

Section D: Dairy production

39. No of dairy animals owned__________________________

	Bulls	Milking cows	Dry cows	Heifers	Steers	Weaners	Calves
Number							

40. Breed_________________________
****Breed:** 1= Holstein, 2= Aryshire, 3= Other (specify)___________________________
41. What breeding strategy is used: ____
1 AI, 2 Bull from neighbor, 3 Own bull, 4 other__________
42. What is the feeding system?____
***dairy feed:** 1= Stall fed at home, 2= In paddocks, 3= Grazing on communal land, 4= Other______
43. What is the average milk production?____________________________
44. Highest milk produced?____________________________________
45. What is the source of feed production water?____
***Water source:** 1= Rain water, 2= Irrigation, 3. Other (specify)________________________________
46. What are the available water harvesting techniques?____
47. Why is farmer opting for dairy production?____
____
48. Did any member of the household obtain agricultural credit in the last 12 months? _______
***Responses:** 1= Yes 2 =No
49. If YES, what was the main purpose of the loan?________

***Purpose: 1=** Purchase farm inputs (e.g. seeds, fertilizers), 2. Buy livestock, 3= Buy/ rent land, 4= Construction of farm structures, 5= Buy machinery and equipment, 6= Payment of labor costs, 7= Other (specify) ____________

Section: Health and Drugs usage

50. What are the common diseases and challenges faced:__________________________________

Disease/ Condition	**Number of cases**					**Tx**
	Per week	Per 2 weeks	Per 3 weeks	Per month	Per 2 months	
Mastitis						
Scours						

Sectipon: CSA

51. What climate smart practices are implemented on the farm?

CSA Practice	**Yes**	**No**
Agroforestry		
Inter cropping		
Minimum tillage		

Crop rotation		
Terracing		

CSD practises

Zero grazing		
Biodigesters		
Solar energy		
Manure utilisation		

52. Did you do any soil analysis/ testing? (yes/No)____
53. What fodder production and preservation technologies are available on the farm?

Section 3: fodder production seasonality

54. What coping strategies are used by farmers in the sites to overcome feed shortages during dry seasons?____

Section 4: Profitability of milk production

1. What is the quantity of milk produced ?

Months	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Milk Prodxn (kgs)												
Milk sold (kgs)												

2. What are the variable costs?____
3. What are the Fixed costs?____
4. What is your monthly/yearly feed requirements?____
5. What is the quantity of feed produced on the plot?____

Fodder	Napier				
Acreage					
Quantity					

Section 4: Support services

1. Who offered trainings on dairy related topics?____
   ***Trainings:** 1. Government, 2. Githunguri Coop Extn workers, 3. Private organization, 4. NGO, 5. Fellow farmer (lead farmer),
2. In which of the following courses were you trained?______________________________________
   ****Courses:**

	1=Yes; 0=No [note all]		1=Yes; 0=No [note all]
Training on fodder establishment and management		Training on fodder conservation & utilization of crop residue	
Training on nursery establishment and management		Training on pasture management	
Training on manure management		Training on composting	
Training on animal health, breeding, calf rearing, milk quality		Climate change awareness sessions	
Training on feed formulation		Field days	
Training on Agroforestry		Workshops/seminars	
Training on biogas		Exchange trips	
Human health		Cooperative laws, rights and obligations	
Financial management		Other (specify)	

3. Which of the above-mentioned trainings where most useful? [Rank from 1=mot important to 3=least important]

1	2	3

4. How useful were the trainings?

1		2		3		4	
Very useful		useful		Not useful		useless	

***Tick appropriate box**

5. What methodologies were used during trainings? (look & learn, Demo plots, incentivized trainings, etc)____
6. What can be done to improve performance of supporters in your area? _________________________
7. What were the easiest innovations you were taught?____
8. What innovations did you implement?____

v) Farm feed economics:

1. What feeds do you grow on plot for your animals?
2. How big is the area for feed production?
3. How much feed do you produce per acre?
4. How many times do you produce feed per year?

5. What costs do you incur when planting fodder?
6. Do you sell feed?
7. In what quantities do you sell and how many quantities?
8. Do you have any interests on loans that you are paying?
9. What other costs do you have on buildings and equipment on plot?

Item	**Variabble Costs**	Depreciation
Yield/ acre per harvest	Planting material/ acre/ Yr	Interest
Number of harvests/Yr	Manure	
Price / 50Kg / tonne	Planting and harvesting costs	
	Hired labour	
	Family labour	
	Permanent labour	
	Packaging material	
	Transport	