Scaling Up Climate Change Mitigation Practices in Smallholder Dairy Value Chains: A case study of Githunguri Dairy Farmer Cooperative Society Ltd, Kiambu County, Kenya.

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Scaling Up Climate Change Mitigation Practices in Smallholder Dairy Value Chains: A case study of Githunguri Dairy Farmer Cooperative Society Ltd, Kiambu County, Kenya.

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ABBREVIATIONS

ICRAF	International Centre for Research in Agroforestry
AFAAS	African Forum for Agricultural Advisory Services
AGM	Annual general Meeting
ASDSP	Agriculture Sector Development Support Program
CIAT	International Centre for Tropical Agriculture
CSA	Climate Smart Agriculture
DFCS ltd	Dairy Farmers Cooperative Society Limited
DFCS	Dairy Farmers Cooperative Society
DRI	Directorate of Research Institute
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GHG	Green House Gas
IEC	Information, Education, Communication
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
KCSAP	Kenya Climate Smart Agriculture Project
KDB	Kenya Dairy Board
KEBS	Kenya Bureau of Standards
MoALF	Ministry of Agriculture, Livestock and Fisheries
MoU	Memorandum of Understanding
NAMA	Nationally Appropriate Mitigation Actions
New KCC	New Kenya Creameries Company
NGO	Non-Government Organisation
SACCO	Savings and Credit Cooperative
UHT	Ultra-High Temperature
UN	United Nations

ABSTRACT

A number of strategies and approaches such as Climate Smart Agriculture (CSA) are being developed and implemented by the Kenya government in collaboration with local and international partners to transform the country's dairy sector to ensure a low-emission development pathway while also improving the livelihoods of male and female dairy producers. However adoption and scaling up of best practices that contribute to mitigation of climate change and variability still remains a challenge especially for smallholder farmers. Research was conducted with an aim of identifying best practices in climate change mitigation in smallholder dairy value chain in order to develop interventions for scaling up of practices that support low-emission dairy development in the Githunguri dairy value chain. The research was carried out on smallholder dairy farmers belonging to Githunguri Dairy Farmers Cooperative Society Ltd. A purposive simple random sampling technique was used to identify 48 smallholder dairy farmers in 2 sub counties of Githunguri (24 farmers) and Ruiru (24 farmers) sub counties. Research methods such as desk study, observation, focus group discussion and survey were applied and research tools including a structured questionnaire and checklists were used to extract data from respondents. Aspects studied in the research included the dairy value chain, chain governance, gender roles in dairy production, forage and fodder management, conservation agricultural practices, dairy animal management and welfare, water resource management, manure management as well as milk collection and transportation to collection centres. Findings from the research established two types of chain governance including market and modular type of chain governance. The research found out that over 90% of respondents were not aware about climate change and climate smart agriculture however it was noted that farmers were already implementing practices that contributed to climate change mitigation. Both men and women were involved in dairy production practices with female doing more of the daily work like ensuring availability of feeds and water for livestock as well as cleaning the cow barn while men made majority of the decision regarding resource allocation. In terms of practices that contribute to climate change mitigation, it was observed that 85% of farmers practiced conservation agriculture, 100% of farmers kept improved dairy breeds such as Friesian and also provided concentrates to increase milk yield. All farmers grew high yielding and drought resistant fodder such as napier, however there was limited diversification in terms of forages planted on the farm. Over 65% of farmers utilized crop residue like maize stovers as feeds and applied manure back to crop and fodder fields contributing less need for purchased inorganic fertilizers. Mitigation practices like composting and biogas production among others were less adopted as indicated by less than 20% of farmers. The research established the main barriers to adoption of climate change mitigation practices were limited awareness as well as insufficient funds to adopt some of the technologies like biogas production. To address these challenges, the researcher suggests that promoters of CSA including Government of Kenya as well as local and international organizations should establish linkages with the cooperative in order to reach out and sensitize farmers on climate change and effective mitigation measures in dairy production and where possible to provide cofunding for farmers to adopt some of the climate smart technologies like biogas production.

CHAPTER 1: INTRODUCTION

1.1 Overview

This chapter provides information regarding the context of the research proposal. This includes the background information about dairy production in Kenya, problem statement, objective and research questions.

1.2 Country brief

Kenya is located in East Africa and is one of the countries in Sub Sahara Africa categorized by Intergovernmental Panel on Climate Change (IPCC) as most vulnerable to climate variability and change (IPCC, 2014). This has an effect on the overall agricultural productivity and the economic development of the country. Agriculture is central to Kenya's economic development and contributes 28% to the country's gross domestic product (GDP) and accounts for 65% of Kenya's total export earnings (GOK, 2017). One of the agricultural subsectors playing an important role in Kenya's socio-economic development, including household food and nutrition security, is livestock. The livestock sub-sector contributes about 19.6% of the Agricultural GDP and about 4.9% of Kenya's Gross Domestic Product (GDP). The sub-sector employs 50% of the agricultural labor force and is the main source of livelihood to over 10 million Kenyans living in the arid and semi-arid lands (ASALs) (GOK, 2017). Despite the enormous contribution of agriculture to Kenya's economy, the sector remains the largest contributor of greenhouse gas (GHG) emissions that lead to climate variability and change. The agricultural sector contributes (58.6%) of total GHG emissions and livestock related emissions account for an overwhelming majority (96.2%) of those emissions (World Bank and CIAT, 2015).

1.3 Overview of the Kenya dairy sector

The Kenya dairy industry is private sector driven and is the largest agricultural sub-sector. The sector provides nutrition, income and employment for approximately 1.8 million people across the dairy value chain including farmers, transporters, traders and vendors, employees of dairy societies, milk processors, input suppliers and service providers, retailers and distributors (MoLD, 2012). According to the Kenya Dairy Board (2014), up to 80% of dairy production in Kenya is carried out by smallholder farmers of with some members organized under dairy cooperative societies such as Githunguri Dairy Farmers Cooperative Society ltd in Kiambu county, Central Kenya. The country has an estimated 3.5 million heads of improved dairy cattle (Friesian, Ayrshire, Jersey and Guernsey breeds and their crosses), and about 9.3 million indigenous animals, however current milk productivity is generally low due to poor and limited feed resources, diseases and poor management (FAO, 2011). Annual milk production from dairy cattle is about 70% of the total national milk output (more than 4.5 billion litres). The Kenya Dairy Board (2014) estimates that 70-80% of the marketed milk is sold in raw form through the informal channels. 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, Githunguri, Meru Union and Daima (KDB, 2015). Major dairy products on the market include pasteurized milk and long-life dairy products such as (Extended Shelf Life and UHT milk), yoghurts, cheese, butter and milk powder. The major feed resources for dairy cattle are natural forage, cultivated fodder and crop by-products as well as commercial feeds such as dairy meal. In terms of water resources, the livestock sector is estimated to use about 255 million litres of water per year which is expected to increase to about 650million litres of water in 2050 yet Kenya is one of the countries said to be water deficit (FAO, 2017a).

1.3.1 Greenhouse Gas Emissions (GHG) in the Kenya dairy sector

The GHG profile for dairy cattle is dominated by methane (NH4) followed by nitrous oxide (N_2O) and carbon dioxide (CO_2) which contribute 95.6%, 3.4% and 1% respectively (FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2017). In Kenya, the dairy cattle sector is responsible for about 12.3 million tonnes CO_2 eq. Estimations from FAO & New Zealand Agricultural Greenhouse Gas Research Centre (2017) indicate that approximately 88 percent of the emissions arise from methane produced by the rumination of cows, 11 percent from the management of stored manure and 1 percent from feed production. Along the dairy value chain, GHG emissions also arise from milk transportation, cooling and processing of milk however the contribution of such emissions in terms of magnitude and significance for the climate are debatable since credible information on the issue specifically for Kenya is lacking (FAO, 2011).

1.4 Kiambu County

Kiambu County is located in the central highlands of Kenya where 85 percent of households are estimated to own dairy cattle (Wambugu et al., 2011). Agriculture is the major economic activity, contributing 17.4 percent of the county population's income (ASDSP, 2014). It is the leading sector in terms of employment, food security, income earnings and overall contribution to the socioeconomic wellbeing of the people. Coffee and tea are the main cash crops, while beans, maize and Irish potatoes are the main food crops. With respect to livestock, dairy, beef cattle and poultry are the major sources of livelihoods. In 2010, it was estimated that the entire county produced 267.5 million kg of milk valued at Kenya shillins 5 billion compared to KES700 million from eggs and 143 million from poultry meat, respectively (ASDSP, 2014). The county has a long history of dairy production and marketing; its proximity to Nairobi city and its suburbs creates a lucrative market for milk and dairy products.

1.4.1 Githunguri dairy Famers Cooperative Society Ltd (GDFCS)

Githunguri Dairy Farmers Cooperative Society was started in 1961 by 31 smallholder dairy farmers with one collection centre. The cooperative is located in Githunguri Sub County, Kiambu County 50 Kilometres north of Nairobi City (AFAAS, 2013). The Cooperative was formed as an initiative to help the smallholder dairy farmers of Githunguri Division, to market their milk. Over the years the cooperative increased its membership to currently 24,936 smallholder dairy farmers. The cooperative has 82 collection centres and 7 cooling centres spread over the catchment area which is mainly the 5 wards of Githunguri sub county. The cooperative processes about 230,000 kilograms of milk per day (GDFCS, 2018). In 2004, the Cooperative commissioned its own milk processing plant to embark on processing and marketing of its own milk products under the flag ship of Fresha Dairy Products (Muriuki, 2006).

1.5 NWO CCAFS project-Kenya

NWO (Netherlands Organization for Scientific Research) is a Dutch organization that aims to ensure quality and innovation in science and facilitates its impact on the society. NWO works in collaboration with CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) to address the increasing challenge of global warming and declining food security on agricultural practices, policies and measures. In Kenya, NWO's research is connected to the CCAFS project "Nationally Appropriate Mitigation Actions" (NAMA) for Dairy Development. NAMA supports stakeholders in Kenya to design/pilot activities to reduce GHG emissions from dairy production (NWO, 2017).A number of strategies and approaches such as Climate Smart Agriculture (CSA) are being developed and implemented by the Kenya government in collaboration with local and international partners to transform the country's dairy sector to ensure a low-emission development pathway while also improving the livelihoods of male and female dairy producers (ICRAF, 2013). However adoption and scaling up of best practices that contribute to mitigation of climate change and variability still remains a challenge especially for smallholder farmers. Therefore, identification and analysis of scalable climate smart practices as well as understanding of the challenges and opportunities in climate change mitigation under smallholder dairy production will help to inform partners and stakeholders in the livestock sector of the practices and measures that ensure reduction in GHG emissions while also sustainably contributing to increased dairy production and income security.

1.6 Problem statement

A number of GHG mitigation initiatives have been developed in the Kenya dairy sector however scaling up of the best practices has remained a challenge (NWO, 2017).

1.7 Objective

To identify best practices in climate change mitigation in smallholder dairy value chains in order to develop interventions for scaling up of practices that support low-emission dairy production in the Githunguri dairy value chain.

1.8 Research questions

Question 1: What are the scalable climate smart best practices that lead to reduced emissions in the Githunguri dairy value chain?
Sub-questions:

a) What is the governance of the dairy value chain under Githunguri DFCS Ltd?
b) What dairy production practices promote climate smartness in the Githunguri dairy value chain?
c) What is the role of gender in ensuring climate smart dairy farming in smallholder dairy production enterprises in Githunguri sub county?

Question 2: What is required to support scaling up of climate change mitigation under Githunguri DFCS Ltd value chain?

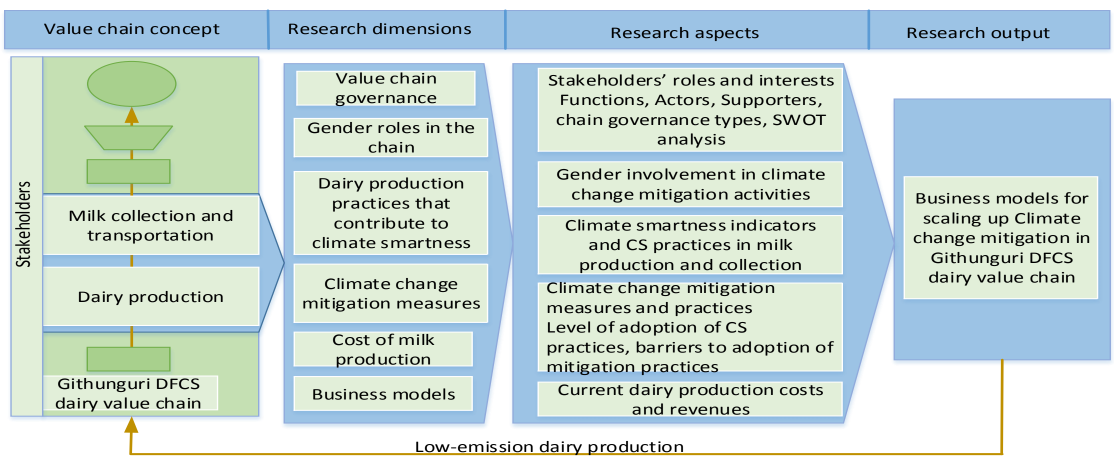
Sub-questions:

a) What is the current level of adoption of climate change mitigation practices in the Githunguri dairy value chain?
b) What is the cost of milk production in the smallholder dairy farms under Githunguri DFCS Ltd?
c) What business models promotes scaling up of climate change mitigation practices in the Githunguri dairy value chain?

1.9 Conceptual framework

The conceptual framework (Figure1) gives an overview of the key concepts, dimensions, research aspects and the output of the research. The research adopted the value chain concept and considered actvivities carried out at the milk production and milk collection nodes of the value chain.

Figure 1: Conceptual framework



CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter presents literature on the different research topics from different sources including reports, journal, books and online sources like google scholar among others.

2.2 Dairy value chain in Kiambu County

A value chain is described by Kaplinsky and Morris (2000) as activities or steps that are required to bring a product or service from conception, through the different phases of production, (involving a combination of physical transformation and the input of various producer services) to delivery to final consumers, and the final disposal after use. Figure 2 depicts the different levels of the value chain from field to fork.

Figure 2: Value chain operations and value addition.

Source: Schrader et al., 2015

Activities along the dairy value chain include input supplying, milk producing, milk collection and bulking, milk processing, trading and consuming. The dairy value chain in Kiambu is comprised of actors, supporters and influencers involved in the different activities and at different level of the value chain. Among the actors are those that are directly or commercially involved in the chain, these include input suppliers, milk producers, milk collection and bulking enterprises, processors, traders and consumers; these are categorised as direct actors. Actors that do not directly or commercially get involved in the chain are called indirect actors or chain supporters or chain influencers. These include financial service providers (banks and credit agencies), NGOs, government, extensionists and researchers among others (KIT, 2006). Table 1 shows the different stakeholders in the Kiambu dairy value chain highlighting their roles and interests.

Table 1: Stakeholders and their roles and/or interests in the Kiambu dairy sector:

Name of the stakeholder	**Role/Interest**
Direct actors	
Input suppliers: Private stockist/Agro-vet	Supply animal feeds, drugs, AI services and equipment to farmers. They also supply different types of equipment to other actors in the chain.
Producers	Keep dairy cattle, produce milk and sell to consumers. 80% are smallholders
Cooperatives (CBE)	Collect bulk and sell milk to processors and sometimes to traders or directly to consumer. Sometimes they also process.
Processors	Process and add value to milk before selling to consumers through supermarkets and shops.
Traders and retailers	Buy milk from farmers and supply to consumers. Retailers include milk bars, kiosks / shops and supermarkets.

Consumers	These are the end users of the milk and milk products.
Chain supporters and influencers	
Universities (Egerton, Nairobi)	Train manpower in areas related to animal husbandry and health, feeds and milk processing
KARI	KARI collaborates with other stakeholder to ensure that milk and dairy products are free from veterinary drugs, residues and disease causing organisms.
SNV	Implementation partner of the Kenya market let dairy programme
Land 'O' Lakes	Trains mainly farmer organizations on feed conservation methods and coordinates various projects on the Kenya dairy sector
Financial institutions	These include banks, savings and credit societies, micro credit institutions. They support dairy actors by providing credit
Ministry of Agriculture, Livestock and Fisheries	National Policy Development Policy formulation and review; Facilitate implementation of policies to create an enabling environment for other stakeholders to operate; Provision of extension and advisory services to other stakeholders; Research and development; Funding of various projects.
County Government	Facilitate implementation of policies to create an enabling environment for other stakeholders to operate; Provision of extension and advisory services to other stakeholders; research and development; funding of various projects; coordination of dairy and veterinary activities at county level.
Kenya Agricultural and Livestock Research Organisation (KALRO)	Provision of dairy research services by Dairy Research Institute (DRI)
Kenya Dairy Board (KDB)	KDB is responsible for policies, strategies and regulations governing the quality of milk delivered to processors and consumers.
Kenya Bureau of Standards (KEBS)	Product standardization and certification

2.2.1 Production and input supply

Majority of the dairy farmers in the in Kiambu are smallholder farmers most of whom are organized under dairy cooperative societies. The county has 16 dairy farmer cooperative societies and produced an estimated 119 million litres of milk in the year 2015 (ASDSP, 2017). The smallholder dairy farms in the area are low-input, low output; however, there are growing numbers of entrepreneurial smallholders that are in dairy as core business. These buy a variety of inputs and use service providers hence a wide distribution network exists of agro-vets or agro-dealers, mainly trading in dairy meals, hay, veterinary products, seeds, fertilizers, chemicals and genetics (AI). Some Cooperatives such as Githunguri DFCS have outlets stores where members can access input supplies on credit and payment of these inputs is effected through checkoff from daily or monthly milk supplied by the farmers (GDFCS, 2018). Medium and large scale dairy farmers often invest in modern commercial dairy production systems and usually transport their milk directly to processors.

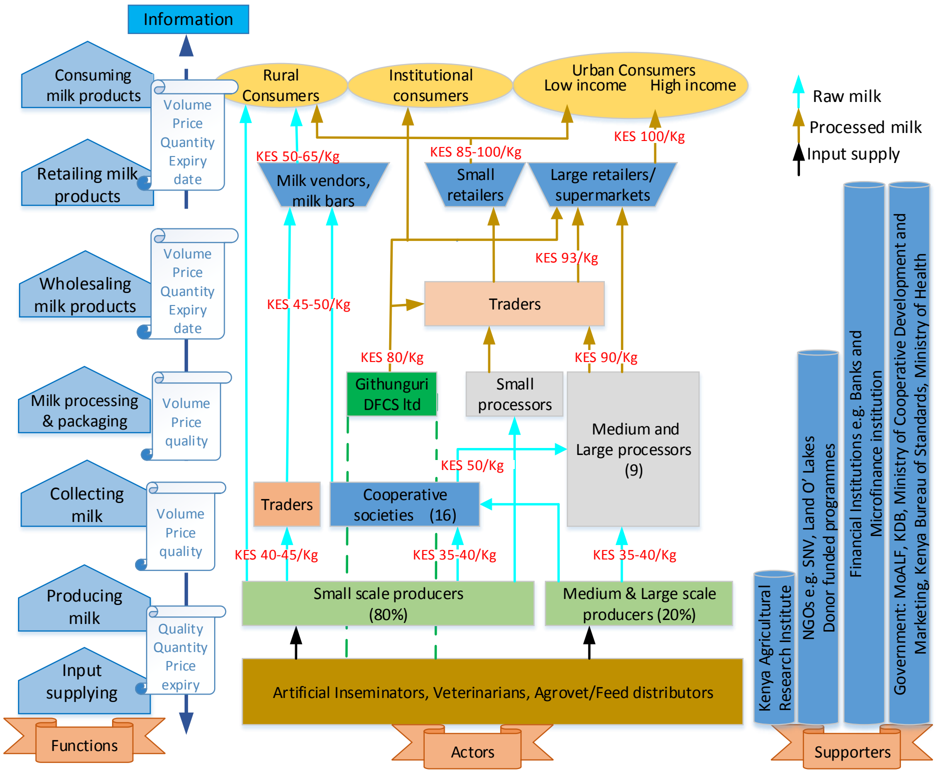
2.2.2 Collection and transportation

Out of the total milk produced by a household, it is estimated that 7% of milk is consumed by calves, 28% consumed on-farm and 65% is marketed, including both formal and informal market channels. According to KDB report (2014), around 20-30% of the marketed milk in Kenya is sold on the formal market while the majority, about 70-80%, is sold on the informal market. In the informal market, milk is usually delivered either directly from mainly smallholder dairy farmers to consumers or through a number of brokers or hawkers (TechnoServe, 2008). The farm gate price per litre of milk through the informal chain in between Kenya shillings 40-45. The informal chain is cash based and most often, milk quality is compromised due to addition of adulterants like hydrogen peroxide and water. Actors along the informal chain include mobile milk traders; milk bars; and shops and kiosks (Muriuki, 2011). These sell milk to consumers at prices ranging from Kenya shillings 50-65 per litre of milk. Preference for selling milk in the informal chain is driven by preference for cash to be able to offset daily expenses especially for smallholder farmers while usually processors that belong to the formal chain pay at the end of the month. The formal market is characterised by smallholder farmers who are normally organized under cooperative societies and milk is collected and transported under a cold chain to the bulking centres and/or to the processing facility. The farm gate price per litre of milk in the formal chain is between 35-40KES depending on the season. Medium and large scale dairy farmers often deliver their milk directly to processing companies. Majority of the cooperatives collect milk from members either directly or through collection points using hired transporters with vehicle, motorbike, bicycles or animal driven carts (TechnoServe, 2008).

2.2.3 Processing, trading and consumption

According to ASDSP report (2017), there are 10 milk processing companies in the county. The major processors include Brookside, New Kenya Co-operative Creameries Ltd and Githunguri DFCS ltd. The processors buy milk at average 50KES per litre from dairy cooperatives, traders or directly from farmers (mainly medium scale and large scale dairy farmers). Once milk is processed, it is delivered by distributors or agents to a point of sale which include wholesale and retail shops at an average price of 90KES per litre. The wholesalers sell a litre of milk at 93KES while retailer sell a litre of milk at an average 100KES to the consumers. A range of dairy products exists on the market which include whole milk (both fresh and long life), yoghurt, ghee, butter, lala and cream (ADSPS, 2017). The consumers of milk from Kiambu county include national consumers, major hotels in Nairobi city, and local consumers around Kiambu county (Katothya, 2017). Figure 3 gives a detailed overview of the Kiambu dairy value chain.

Figure 3: The dairy value chain in Kiambu



Source: Adaped from Katothya, 2017

2.3 Sustainability of the dairy value chain

The dairy sector in Kenya faces numerous issues in terms of challenges and opportunities that characterize the sustainability of the supply chain, institutional governance and the innovation support systems along the value chain. Combined, these three themes help to understand the robustness, reliability and resilience of the dairy value chain and can be applied to assess the competitiveness of the different chain actors (Rademaker et al., 2016). Table 2 give the sustainability of the value chain in Kenya highlighting the strength, weakness, opportunities and threats in the value chain.

Table 2: Sustainability of the dairy sector in Kenya

	Strength	**Weakness**	**Opportunities**	**Threats**
Economic robustness	Availability of large population of good quality dairy breeds Growing formal sector with incentive for supply of quality milk Increasing local and global market for dairy products	Insufficient milk production and supply Low overall value addition due to large quantities of milk sold in raw form High cost of production; low milk quality; high milk losses Inadequate access to input supplies	Growing demand for locally produced milk products Growing on-farm and commercial feed production and conservation Increased demand for quality services like animal genetics Entry of young farmers eager to commercialize dairy production	Decreasing farm sizes High cost of power Public concern with milk quality (antibiotics)

		such as AI, quality feeds and extension services High fragmentation of the value chain and low supplier loyalty	Provision of embedded services by cooperatives to reduce side selling of milk	
Environmental robustness	Favorable agro-climatic conditions Integrated crop-livestock farming ensuring nutrient recycling	Limited attention to reduction of greenhouse gas emissions Limited awareness on the potential impact of diary production and processing	Promotion of biogas production Increased support for appropriate climate change mitigation actions	Loss of indigenous cattle breeds Increased case of climate change impacts like drought and floods
Social robustness	Tradition of cattle keeping Major source of livelihood Self-help and farmer cooperatives lead to community development	Dairy farming is less attractive to the youth due to limited access to production factors	Employment creation along the dairy value chain	Public health at risk due to poor quality milk

Source: Rademaker *et al.*, 2016

2.3 Overview of value chain governance

Value chain governance refers to the formal and informal arrangements or relationships between the different chain actors that operate the range of activities required to bring a product or service from inception to its end use. It implies that interactions in the chain are frequently organized in such a way that actors can meet specific requirements in terms of production, processing and logistics (Dietz, 2012). In such types of arrangements, there are actors who take the leading role to ensure that all other actors in the value chain are able to comply with the requirements and standards for the whole chain to be profitable; and these are called Lead actors. The lead actor in value chain governance can be a firm (buyer or producer) within the value chain or public or private institutions located in the environment of the chain. In the Kiambu dairy value chain, the lead actors can be middlemen especially in the informal market while cooperative organizations and/or processors in the formal value chain can take the leading role.

2.3.1 Key parameters in value chain governance

It is the responsibility of the lead actor to set and enforce parameters to which all other actors must comply. These parameter include; the nature of the product which may include quality of the milk to be produced; how the product is to be produced and how much and when the product is to be produced which may include volumes of milk, delivery times, equipment to be used for milk handling and specific locations where the milk is to be collected. The lead actors are also responsible for ensuring that all actors in a value chain comply with the rules set by the government. Lead actors are therefore responsible for setting rules, monitoring and also facilitating compliance with rules that pertain to a set of the parameters (Dietz, 2012).

2.3.2 Instruments of value chain governance

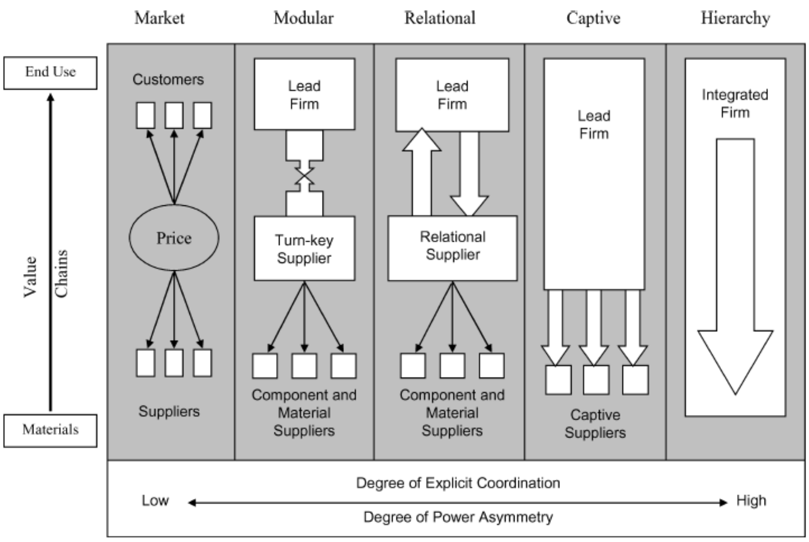
For value chains to operate smoothly, there is need for instruments that help to ensure compliance of all chain actors. These include; Contracts between value chain actors, Standards for products and processes, Self-regulatory systems in value chains, Management of producer organizations, Government regulatory frameworks, Unwritten norms that determine who can participate in a market as well as expectations from the public.

According to Dietz (2012), interactions in value chains run either in vertical or horizontal direction. Vertical linkages are those between actors that have different market functions; horizontal linkages exist among the actors who have the same market function in a value chain. Linkages within a value chain are mostly business linkages, e.g. contracts between sellers and buyers, and can be of formal and informal character. Linkages may include also exchange of information and know-how.

2.3.3 Types of governance systems

Governance is an important instrument to improve the performance of value chains and sustain/increase their competitive advantage. According to Gereffi et al., (2005), the type of value chain governance is determined by three main factors: the complexity of transactions (products and processes); the ability to codify or explain these transactions, and the capability of suppliers to perform these transactions. Value chain governance types also differ by the relationships that value chain actors have with each other and with the lead firm. The connections between activities within a chain can be described along a continuum extending from the market, characterized by "arm’s-length" relationships, to hierarchical value chains illustrated through direct ownership of production processes. Between these two extremes are three network-style modes of governance: modular, relational, and captive. Figure 4 gives the different vale chain types accoding to Gereffi et al., 2005.

Figure 4: Value chain governance types



Source: Gereffi et al., 2005

In the market type of chain governance, transactions require little or no formal cooperation between participants, the cost of switching to new partners is low for both the producer and the buyer. In the modular type of chain governance, the producers must make products or provide services to the buyers specifications. For the relational type of governance, the producers and buyers rely on complex information that is not easily transmitted or learned, and where quick adaptation may be required. Captive chain governance is where small suppliers are dependent on a few buyers who often wield a great deal of power and control whereas hierarchical chain governance is characterised by vertical integration and managerial control within a set of lead firms that develop and manufacture products in-house, usually common when product specifications cannot be codified, products are complex or highly competent suppliers cannot be found (Dietz, 2012).

2.4 Gender integration in the dairy value chain

In smallholder households across Kenya, just like in many other African countries, dairy production is a family operation in which all family members including men, women, and children contribute to production, processing, and marketing activities (Gallina, 2016). Studies assessing the gender division of labor in dairy farming indicate that women farmers play a predominant role especially in tasks that are around the homestead such as milking, watering, cleaning out the pens, and feeding the animals (Njarui et al., 2012). Traditionally, women have also been involved in the marketing of milk and other dairy products. Men on the other hand tend to have larger roles in activities that are carried out weekly or seasonally such as spraying or planting fodder as well as seeking for veterinary treatment, artificial insemination, and marketing of live animals and meat (Njiku et al., 2011). According to Njarui et al., (2009) hired labor contributes between 50-70% of the total labor required to run daily operations in the dairy enterprise in rural and peri-urban areas of Kenya while children contribute less than 10% of the labor force in the dairy enterprise. Along the value chain, Safa (2017) notes that women involvement decreases at the more lucrative activities such as processing and retail nodes.

2.5 General overview of dairy production in Kiambu

Kiambu County is located in the central highlands about 30 Km from Nairobi city. Its nearness to the Nairobi city makes dairy production a lucrative business. About 85 percent of households in the county are estimated to own dairy cattle (Wambugu et al., 2011). The county experiences ambient temperatures averaging about 18^0C and bimodal rainfall hence agriculture is largely driven by rainfed system.

A variety of production systems are employed by smallholder dairy farmers in the area, ranging from stall-fed cut-and-carry systems, supplemented with purchased concentrate feed to free grazing on unimproved natural pasture in the more marginal areas. Extensive diary production is not possible since the area has a high population density. Exotic dairy breeds such as Friesian, Ayrshire and Holstein are the most kept especially under stall-feeding system, while free-grazing dairy animals are mainly cross-bred cattle (FAO, 2011).

Dairy production systems in Kiambu can also be divided into three broad categories which include large-scale, medium scale and small-scale production systems. The differences between the dairy systems are in their sizes of operation, level of management and use of inputs. The small-scale or smallholder dairy production system is dominant with over 80% of dairy farmers under this system (Katothya, 2017). The average farm sizes of the smallholder dairy farmers in central highlands of Kenya is 5 acres and average herd size is 5 dairy cattle, with average milk production of 10 litres per cow per day. Medium scale dairy farmers own 7-10 dairy cattle and produce approximately 15-20 litres of milk per cow per day, these make up 10% of the dairy producers in the county. Large-scale dairy farmers own 10-30 dairy cattle and produce approximately 20-25 litres of milk per cow per day and these also make up 10% of the dairy farmers in the area (Mugambi et al., 2014).

The major feed resources for dairy cattle in the area include natural forage, planted fodder such as napier grass and maize, cut baled grass, crop residues and brewers waste. These are supplement by concentrates (Staal et al., 2016). According to Mugambi et al., (2015), dairy production is based on the close integration with crop production mainly maize, which is accompanied by cash crops such as coffee or tea. The crop-livestock system employed by smallholder farmers allows for diversification of risks, and recycling of wastes thus preventing nutrient losses, adding value to crops and crop products. The crop-livestock farming system buffers against climate fluctuations, offers diversified income sources for farmers and also provides an alternative use for low-quality roughage (Mugambi et al., 2015). The county has fertile volcanic soils that support fodder and pasture production throughout the year, well established infrastructure such as roads and electricity which enhance quick transportation of milk and milk product processing as well as a high population which offers ready market for the dairy products (ASDSP, 2017).

2.6 Climate change impact on dairy production

Climate change and agriculture are inextricably linked since agriculture still depends much on the weather especially in Kenya. Smallholder livestock farmers are among the most vulnerable to climate change which is being experienced through extreme temperature variations and change in rainfall patterns (FAO, 2016). In Kenya, climate change has led to declining livestock production due to direct and indirect impacts to both livestock and their production systems. In grazing systems, the direct impacts include increased frequency of extreme weather events; increased frequency and magnitude of droughts and floods; productivity losses due to physiological stress occasioned by temperature increase; and change in water availability. The indirect impacts stem from agro-ecological changes and ecosystem shifts that lead to alteration in fodder quality and quantity; change in host-pathogen interaction resulting in increased incidences of emerging diseases; and disease epidemics. In nongrazing systems, the direct impacts include change in water availability and increased frequency of extreme weather events while the indirect impacts include increased resource prices (e.g. feed, water and energy), disease epidemics and increased cost of animal housing (e.g. cooling systems) (Kenya Climate Smart Strategy, 2017).

2.7 The Kenya dairy NAMA and Climate Smart dairy production

Nationally appropriate mitigation actions (NAMAs) are a type of planning instrument for national mitigation. In the Kenya dairy sector, the main objective of the dairy NAMA is to trigger low-carbon development in the dairy sector through the introduction of climate-smart livestock practices and to bring the dairy production sector of Kenya onto a low carbon and more resilient path. More specifically, the dairy NAMA aims at transforming the Kenyan dairy sector and significantly reduce greenhouse gas (GHG) emissions while also achieving other important social, economic and environmental benefits (MoALF, 2017). NAMA supports stakeholders in Kenya to design/pilot activities to reduce GHG emissions from dairy production (NWO, 2017). The key approach envisioned within the dairy NAMA is to improve dairy productivity and reduce emissions by assisting and incentivizing private-sector investment in low-emission, climate resilient, gender inclusive dairy extension services, enabling investments in energy efficiency and clean energy technologies in milk collection, chilling and processing and supporting adoption of household biogas technology. The lead agency in the development and implementation of the Kenya dairy NAMA in the World Agroforestry Centre (ICRAF) in partnership with UNIQUE forestry and land use and in close collaboration with UN FAO, IFAD and ILRI. Kenyan partners include the State Department of Livestock at the Ministry of Agriculture, Livestock and Fisheries (MoALF), the Ministry of Environment and Natural Resources (MENR) and the Kenya Dairy Board. Throughout the NAMA development process numerous other stakeholders have been involved, including dairy processors, dairy sector association representatives, commercial hay growers, financial institutions, biogas companies, development organizations and national and international research organizations (CGIAR, 2018).

2.8 Assessment of Climate Smartness of agricultural practices

There are a number of ways of assessing the climate smartness of agricultural practices, however one of the ways that was developed through collaborations between CIAT and the World Bank to identify country specific baselines on CSA in Africa, Asia and Latin America and the Caribbean involved use of categories of indicators (and sub-indicators) related to the management and use of carbon, nitrogen, energy, weather, water and knowledge, using a set of proxies for each to evaluate climate-smartness as shown in table 3 (World Bank and CIAT, 2015).

Table 3: Indicators for climate-smartness of agricultural practices

Smartness category	Indicators
1. Water smartness	1.1 Allows reduction in the volume of water consumption per unit of product (food) (l/kg/ha, l/ha etc.)
	1.2 Enhances water quality available for agricultural production (by reducing chemicals, sediments, metals in the water bodies)
	1.3 Enhances water and moisture retention in soils (mm/m, %)
	1.4 Promotes protection/ conservation of hydric sources (especially headwaters)
	1.5 Promotes water capture/ use of rainwater for agricultural production
2. Energy smartness	2.1 Allows for reduced consumption of fossil energy (reflected by savings in fossil fuel combustion, or electric energy consumption [J/kg, J/h, etc.])
	2.2 Promotes the use of renewable energy sources (e.g. wind and/or solar energy, biogas, etc.)
3. Carbon smartness	3.1 Increases above- and below-ground biomass (ton/ha; kg/m^2 etc.). This is related to the mitigation pillar in terms of carbon dioxide (CO_2) capture (plant biomass, wood etc.).
	3.2 Enhances the accumulation of organic matter in soils (soil carbon stock) (Soil Organic Carbon (SOC) or Soil Organic Matter [SOM]: %; kg/ha; g/m^3; kg/m^3). Refers to the mitigation pillar in terms of CO_2 capture (increases in soil Carbon and indirectly improvement of biological and physical soils conditions that impact the greenhouse gas [GHG] emissions.)
	3.3 Reduces soil disturbance (reflected in number of hours of tractor labor, application of alternative soil management techniques, etc.). Refers to the mitigation pillar in terms of CO_2, reducing carbon emissions (mainly emissions associated with tillage process)
	3.4 Promotes techniques to better manage the quality of animal diet and/or manure in livestock systems (manure management and animal husbandry mitigation practices, etc.)
4. Nitrogen smartness	4.1 Reduces the need of synthetic nitrogen-based fertilizers (e.g. kg/ha/year)
	4.2 Reduces nitrous oxide (N2O) emissions (by adopting better techniques of fertilizers use and soil management practices). Reflected in, for instance, reductions in number of grams of N2O/m2/year.
5. Weather smartness	5.1 Minimizes negative impacts of climate hazards (such as soil degradation, effects of flood or prolonged drought events among others).
	5.2 Helps prevent climatic risks (refers to practices that allow farmers be more prepared to mitigate climate risks, such as water reservoirs, early warning systems, heat/, water stress- pests- and diseases- tolerant/ resistant varieties, etc.)
6. Knowledge smartness	6.1 Allows rescuing or validates local knowledge or traditional techniques.

Source: World Bank and CIAT, 2015

Through this system of assessment, a number of CSA practices were identified for the different agricultural production systems. Specifically for dairy production systems, practices such as improved pasture management, use of high productive cattle breeds, improved manure management through composting and production of biogas as well as grass-legume association and use of improved pastures among other practices were identified to contribute both to reduced greenhouse gas emissions and improved income for farmers (World Bank and CIAT, 2015). In crop-livestock systems, practices such as minimum tillage, crop rotation, mixed cropping, agroforestry, terrace or contour farming system, nutrient and irrigation management can increase organic matter and soil moisture conservation, improve crop and fodder yields, water and nutrient use efficiency and as such can reduce greenhouse gas emissions from agricultural activities (Sapkota et al., 2015).

2.9 Climate change mitigation measures in livestock production

Most of the climate change mitigation measures are at the same time adaptation measures and offer multiple-win opportunities for farmers in developing countries (GIZ, 2014). In a study to document potentials for greenhouse gas mitigation in agriculture, GIZ identified a number of important mitigation measures connected to livestock husbandry and grassland management as shown in table 4.

Table 4: Climate change mitigation measures in livestock and grassland management

Theme	Mitigation measures
Livestock productivity	Increasing livestock productivity within sustainable limits (i.e. milk yield/cow, lifetime efficiency of cows, Increasing livestock productivity through improved herd and pasture management, breeding, and veterinary services.
Increasing grass land productivity	Managing grazing intensity (stocking rate, rotations and their timing). Including deep-rooted fodder species and legumes in fodder crops and pastures while reducing synthetic nitrogen fertilizer. Optimizing nutrient allocation of manure across the farm Avoiding fires, especially if late and uncontrolled and favouring (fodder) bushes and shrubs on pastures and rangeland
Long term management and animal breeding	Optimizing lifecycle of animals to reduce lifetime emissions (favourable ratio between lifetime and product). Optimizing the balance between grassland and cropland concerning the factors of carbon sequestration, nutrient management and food production. Optimizing recycling of residues and by-products that can serve for animal feed
Improved feeding	Feeding more concentrates to ruminants to improve productivity and reduce enteric methane (even though volatile GHG in manure is increased).
Manure management	Avoiding wet storage of manure, using solid coverage and favour cooling/shading. Capturing methane emissions for bioenergy use.

Source: GIZ, 2014

2.10 Cost of production on smallholder dairy farms

High on-farm production costs and high supply chain transaction costs are a key bottleneck in the development of Kenya's dairy sector. Measuring the cost of production is important for a farmer to know whether or not his farm is making profits and therefore to make informed decisions that can contribute to improved farm productivity in a sustainable way. Up to date information on the cost of production on different farming systems under different agro ecological zones is important for different chain actors to adequately address farm and chain inefficiencies. According to Ndambi *et al* (2017), farm advisors in particular lack a tool that aids them in advising farmers on better farm management, in order to improve farm efficiency by addressing cost of production. A number of cost approaches have been designed to meet one or more of three major goals; Supporting farmers to improve farm management and economic performance; Supporting researchers and policy makers to identify interventions to improve on farm profitability.; Supporting processors and policy makers in setting milk prices and in identifying adequate farmer support interventions.

2.11 Overview of business models for scaling up agricultural production

With the current trend of climate change, which impacts heavily on livestock and the environment on which the livestock thrive, sustainability of dairy production will require that farmers and other actors along the value chain undertake an environmental focus. This therefore highlights the need for environmental oriented agricultural business and advisory services in addition to a number of other approaches that provide farmers and other actors with business services. Work done by Wongtschowski *et al.,* (2013) identified agricultural business services to include: rural business development services, agricultural business development services, market oriented agricultural advisory services and value-chain-development advisory services.

Farmers and other local actors rely on two broad categories of services to make farming a business. Wongtschowski *et al.,* (2013) identified these services to include; provision of tangible goods such as money to invest, transport, equipment among others; and business services such as technical advice, contacts and information. Likewise for the environmental oriented agricultural business and advisory services that seek ensure a shift in focus towards the environmental sustainability, such categories of services will be required. Tangible items can be supplied by a range of companies and organizations for example banks and micro finance institution offer credit along with other financial services, climate change and climate smart agriculture oriented institutions can offer research, training and information dissemination while ecofriendly oriented companies like biogas companies can offer specialized services such as installation of biogas plants and other support services in order to ensure resilience of agricultural production systems and achieve environmental sustainability. Sometimes such services can be subsidized by governments and external donors. Where this is not the case, farmers should be prepared to pay for at least part of the cost. In contrast business services involve knowledge and skills rather than objects that one can hold. They embrace the non-tangible, non-storable items provided to farmers in order to increase, directly or indirectly, the productivity of their resources. These services are provided through a range of methods such as: training, coaching, demonstrations, meetings, discussions, coordination, facilitation, documents, announcements, etc.

There are various business models that service providers use when bringing services to clients. Wongtschowski *et al* (2013) identified seven different business models and clustered them into three categories: free, subsidized and fully paid as indicated in table 5.

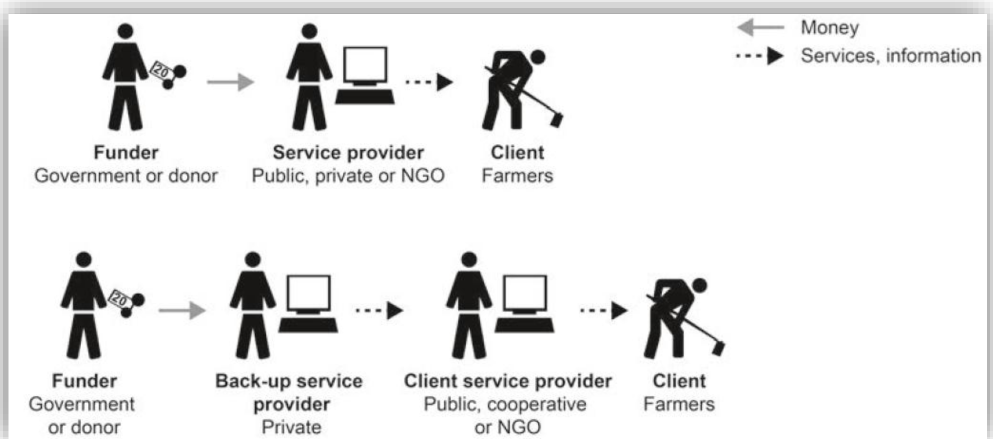
Table 5: Overview of business models

Cluster	Business model	Description	Funder	Service provider	Clients
A Free services	A1	Largely free services	Donor, government	Public or private	Farmers, small enterprises, other service providers
	A2	Paid by companies, delivered to farmers	Companies	Private	Farmers, small enterprises
	A3	Voucher	Government, donor	Private	Farmers, cooperatives
B Subsidized services	B1	Part-payment by farmers	Government, donor Fees, in-kind contributions	Private	Farmers (group)
	B2	Subsidized cooperative services for members	Government, donor Membership fees	Cooperative	Cooperative members
C Fully paid services	C1	Paid by client	Paid by client	Private	Entrepreneurs, cooperatives
	C2	Embedded services	Client: embedded in price paid for other transactions	Input or output company	Farmers

Source: Wongtschowski *et al* (2013)

There are a number of ways in which business models can be organized. Figure 5 illustrates some of the ways how the different models can be organized, in this case highlighting government or donor as the funder of business services.

Figure 5: Business model A1: Government or donor pays for services to farmers



Source: Wongtschowski *et al.,* (2013)

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter outlines detailed information about the study area, research design and tools used during data collection and analysis. It also gives a detailed description of the study population and data sources for the different research questions.

3.2 Study area description

3.1.1 Geographical location

The research study was conducted on smallholder dairy farmers organized under Githunguri Dairy Farmers Cooperative Society Ltd in two (2) sub counties of Kiambu County, namely; Githunguri and Ruiru sub counties. Kiambu County is located in the central region of Kenya (Figure 6) and lies between latitudes 0^0 25‘and 1^0 20‘South of the Equator and Longitude 36^0 31‘and 37^0 15‘East. The county borders Nairobi and Kajiado Counties to the South, Machakos to the East, Murang’a to the North and North East, Nyandarua to the North West and Nakuru to the West. The county covers a total land area of 2,543.5 Km^2 with 476.3 Km^2 under forest cover and has a total population of 1.6 million according to the 2009 Kenya Population and Housing Census. According to Wambugu, et al., (2011), the county has a long history of dairy farming with 85% of households estimated to own dairy cattle.

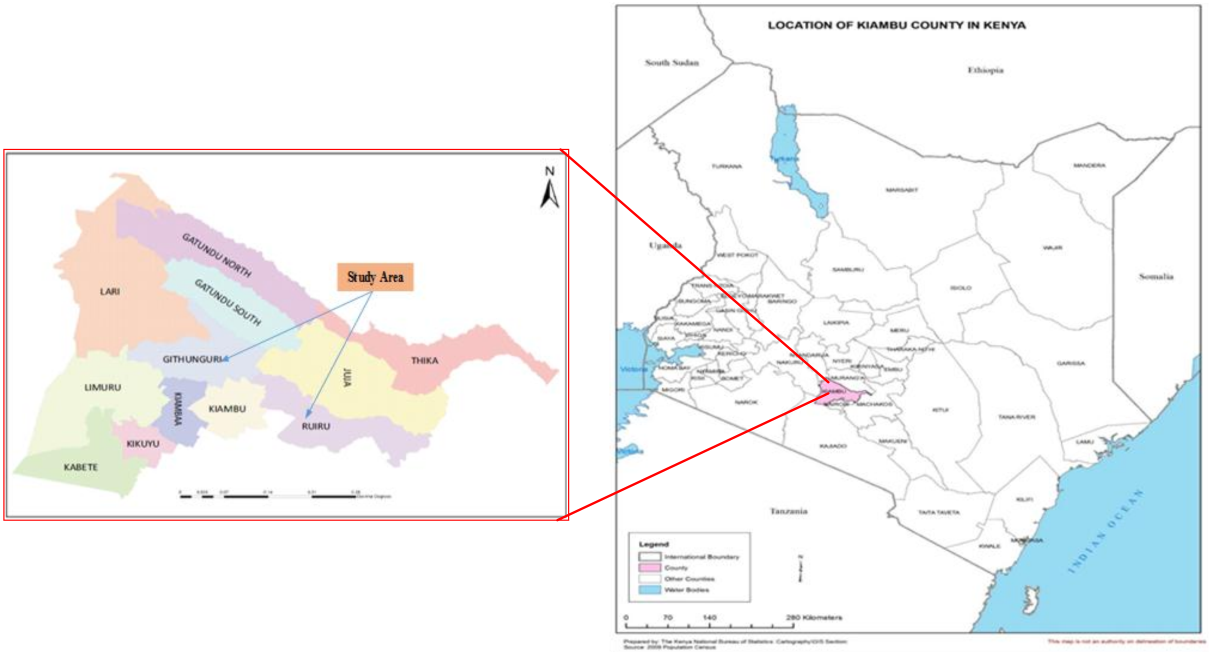
3.2.1 Topography and physical features

Githunguri and Ruiru are two of the 12 sub counties in Kiambu county. The county is subdivided into four zones including Upper highland, Lower highland, Upper midland and Lower midland zones. Githunguri sub county lies in the Lower highland zone at an altitude between 15,00-18,00 metres above sea level and is generally a tea and dairy production zone. The sub county has red volcanic soils which are very fertile and support a range of crops and dairy farming. Zero grazing is the major system of livestock production where feeds are cut and supplied to cattle in their housing units. Ruiru sub county is located in the Lower midland zone at an altitude between 12,00-1360 metres above sea level. The sub county has shallow sand-clay soils that are poorly drained and receives low rainfall which severely limits agricultural development in the area. The area supports growth of drought resistant forages. Both sub counties are characterized by farmers owning small pieces of land due to high population density in the county hence majority of dairy farmers are smallholder farmers (Kiambu, 2018).

3.2.2 Climatic conditions

Generally, the county receives bi-modal rainfall with long rains between Mid-March to May followed by a cold season between June and August, short rains between October to November. The county receives higher rainfall of about 2000mm in the higher areas including Githunguri sub county while low rainfall of about 600mm is received in the lower areas where Ruiru sub county is located. Temperatures range from 7^0C in the upper highlands to 34^0C in the lower highlands with July and August being the coldest months while January to March are the hottest months. Such a wide range of climatic conditions support fodder growth which contributes to thriving of livestock production (Kiambu, 2018).

Figure 6: Map of Kenya showing location of Kiambu county indicating Githunguri and Ruiru sub counties



Source: *Google Maps, 2018*

3.3 Gaining access to the research area and conducting interviews

The research involved a team of three (3) students all from Van Hall Larenstein University of Applied Sciences specializing in Livestock value chains with each student focusing on a different topic. Together with the supervisor from the University, the team made contact with the officials from Githunguri Dairy Farmer Cooperative Society Ltd through phone calls and email contacts and organized an introductory/research orientation meeting. This meeting was held at the Cooperative premises in Githunguri town at the beginning of the research and involved an official from the Extension department together with selected extension officers and some few farmers, total attendance had about ten participants. The meeting was intended create rapport and to gain better understanding of the organization and operations of the dairy cooperative as this would help the research team to effectively prepare for field work.

3.4 Research design and strategy

The research aimed at identifying best practices in GHG mitigation in smallholder dairy value chains in order to generate pathways for scaling up of sustainable climate smart best practices that support low-emission dairy production in the Githunguri dairy value chain. Therefore the research involved carrying out desk study to get acquainted with literature about the study area as well as smallholder dairy production under Githunguri dairy farmers cooperative society. The desk study also sought to capture literature on climate change, climate smart agriculture and greenhouse gas mitigation among other aspects. Research tools such as questionnaires and checklists were developed during this phase. Practical aspects such as areas of operation of the cooperative, activities of the cooperative as well as location and access to farmers were discussed in the orientation meeting. Another meeting was organized with extension workers to discuss and validate the questionnaire and also to plan for actual field visits. The questionnaire was then pretested on three dairy farmers within the study area and adjusted to ensure clarity. In addition to desk research, data collection also involved conducting a survey on smallholder dairy farmers, interviews, focus group discussions as well as farm observations. Data collection lasted for two months between July to August, 2018. During data collection, the main means of transport was a motorcycle which allowed quick access to dairy farmers in their local settings. Motorcyclists were hired as and when the researcher had to visit the field to conduct interviews. In order to address the issue of language barrier, extension officers under Githunguri dairy cooperative were hired to offer translation services but were also very key in setting up face to face meetings with respondents and accessing farmers homes.

3.5 Data collection

This section gives more detail on the methods of data collection that were employed in the research.

3.5.1 Desk research

Desk research involved a review of relevant literature from secondary data sources such as reports, journals, books and credible online sources such as Google scholar among others. This helped to generate data on different research aspects such as dairy herd management practices, conservation agriculture practices, feed production, climate smart dairy production, climate change mitigation, water resource availability, Githunguri dairy farmers cooperative society Ltd as well as gender involvement in climate change mitigation.

3.5.2 Observation

A farm transect walk was conducted on smallholder farms to gather more supportive information through observing the different dairy production practices and to identify climate change mitigation practices in the study area. The observation method also helped to identify water management practices and technologies that support or hinder climate change mitigation.

3.5.3 Focus group discussions

The focus group discussion was organized at a catholic church premise in Githunguri town to ensure that participants were secure and free to interact. A total of six smallholder dairy farmers (4 male and 2 female) who had previously been interviewed attended the discussion along with one extension officer to translate and also to contribute to the discussion. The discussions sought to collect in-depth data on gender participation in dairy production practices that contribute to climate smart agriculture, farmer perceptions on climate change as challenges and solution for adoption of the different climate smart practices. Different participatory methods were applied such as brainstorming and question and answer sessions among others.

3.5.4 Key Informant Interviews

Key informant interviews were relevant for collecting qualitative data. These were conducted through use of tailored made checklists that were administered to different key informants. Respondents in this regard included the Head of extension department of Githunguri DFCS, representative from Takamoto Biogas company (NGO), livestock extension officers, water officer, milk collection agents, milk grader, marketing officer, retailers (shop attendants) and stores personnel. The checklists helped to guide the interviews that aimed at collecting data on key aspects of the research such as the operations under Githunguri DFCS dairy value chain, value chain governance as well as general information, ideas, perceptions, attitudes and experience about climate change and climate smart dairy farming among others.

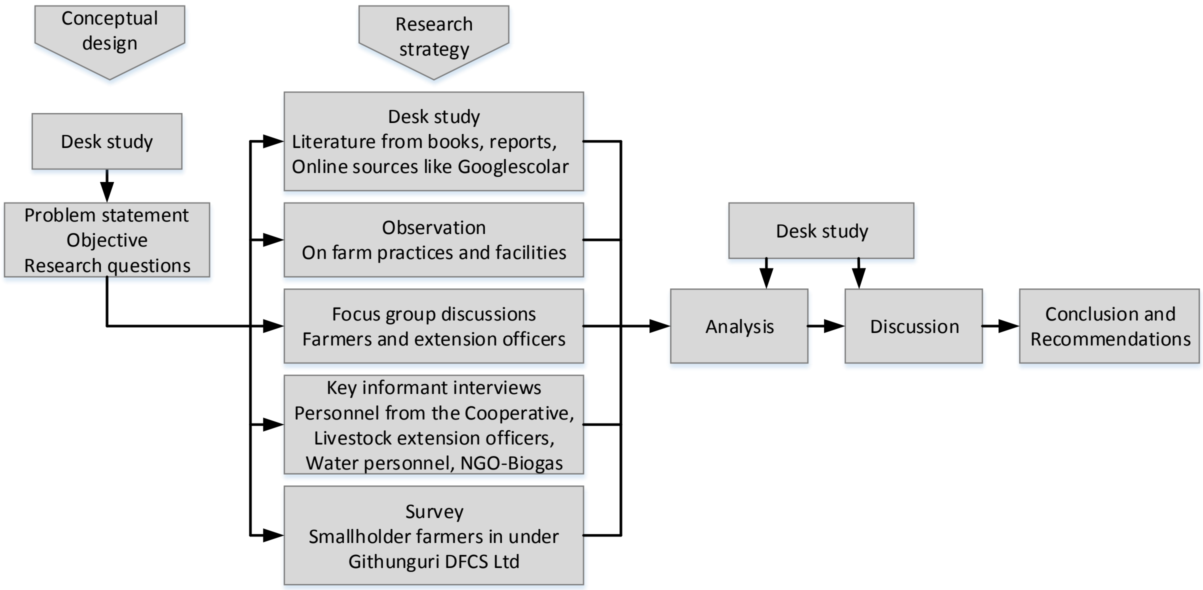
3.5.5 Survey

A farmer survey was conducted on smallholder dairy farmers organized under Githunguri Dairy Farmers Cooperative Society Ltd carrying out dairy farming in Githunguri and Ruiru sub counties. A semi-structured questionnaire (Annex 1) was administered to 48 smallholder dairy farmers with the help of the extension officers to translate for those who could not easily express themselves in English. The questionnaire sought to collect both qualitative and quantitative data and was applied mainly to household heads (both male and female) or members of the household who were in position to make decisions regarding farm management operations. The questionnaire was divided into sections to effectively capture data on the different research aspects. These sections included background information of the household and the respondent, landholding system, forage and fodder management, conservation agricultural practices, dairy animal management and welfare, water resource management, manure management as well as milk collection and transportation to collection centres. Collecting data from different gender perspectives was vital to enrich findings of the research. A smart mobile phone was used to capture voice, still photos and video data which were used to further inform the researcher during analysis and presentation of findings.

3.6 Research framework

The research framework is the schematic representation of the conceptual design and the research strategy as shown in figure 7.

Figure 7: The research framework



Source: Adapted from Verschuuren and Doreweerd, 2010.

3.7 Target population, sample size and sampling technique

The target population used in this study were smallholder farmers belonging to Githunguri Dairy Farmers Cooperative Society Ltd. A purposive simple random sampling technique was used to draw a sample of 48 smallholder dairy farmers from the two sub counties (24 from Githunguri+24 from Ruiru) of which 8 were involved in biogas production. These farmers operated under different milk collection routes with in Githunguri and Ruiru. This was done to ensure that the sample would as much be representative of the whole population as possible. A total of 12 key informant interviews were also held to ensure that the objective of the research was realized. In total, 60 respondents from the two sub counties of Githunguri and Ruiru were interviewed for this research as shown in table 6.

Table 6: Breakdown of respondents

Sub county	Smallholder dairy farmers	Key informants
1. Githunguri	24 (7)	Head of Githunguri DFCS extension department, 2 Milk collectors, 1 Milk grader, 1 Livestock extension officers, 1 Water officer, 1 Marketing officer, 1 Biogas personnel (NGO), 2 Retailers, 1 Stores personnel
2. Ruiru	24 (1)	1 Livestock extension officer
Total	48 (8)	12

(8)Smallholder farmers involved in biogas production

3.8 Data processing and analysis

Both qualitative and quantitative data were collected during the research. Quantitative data was collected using questionnaires during the survey. After the survey, questionnaires were coded and data entered into appropriate computer software which included Microsoft Excel version 2010 and Statistical Package for Social Science (SPSS) version 25. Descriptive statistics were used to analyze the data which included background information on surveyed household and the respondent, landholding system, forage and fodder management, conservation agricultural practices, dairy animal management and welfare, water resource management, manure management and fertilizer use. The analyzed data was summarized and presented in appropriate tables and figures such as pie charts and graphs.

Qualitative data was collected through interviews, discussions and observations. The collected data included data on the dairy value chain under Githunguri DFCS, value chain governance, farmers perceptions on climate change, identification of climate smart dairy farming and GHG mitigation practices, gender roles, as well as challenges and opportunities for adoption and scaling up of climate smart dairy farming practices. The collected data was descriptive, narrative and in model form. Findings were transcribed and data processing was supported by use of the ground theory method which involved coding and grouping data according to different categories. Appropriate tables such as the farm transect matrix, stakeholder matrix, SWOT, gender matrix, among others were developed to give clear and concise information that provide answers to the research questions and supports the drawing of conclusion and recommendations. Microsoft Visio version 2013 was used to generate figures and models which include value chains map, Githunguri DFCS organogram, dairy hub model and the business models (Table 7).

Table 7: **Summary of data sources and analysis techniques**

Data set	Source of data	Data analysis technique
Demographic data	Questionnaires	SPSS
Governance of the dairy value chain	Key informant interviews	Stakeholder matrix Value chain map SWOT Chain governance models

CSA and GHG mitigation practices in dairy production in Githunguri and Ruiru sub counties	Farm observation Questionnaires Key informant interviews	Transect matrix SPSS Microsoft Excel
Role of gender in GHG mitigation	FGD Questionnaires	Gender matrix SPSS
Level of adoption of mitigation measures	Questionnaires	SPSS
Cost of milk production	Farm case study	Microsoft Excel
Scaling up of mitigation practices	Key informant interview FGD	Business models

3.9 Ethical issues

Respondent were informed of the objective of the research and were requested to consent before being interviwed**.**

3.10 Limitations during the research

The researcher was a foreigner and did not understand the local language however, he was able to conduct interviews with the help of extension officers for translation, hence the researcher relied on translation by the extension officers to fill the questionnaires which may have influenced .

During the course of data collection it was noted that there were no observed comparable differences in terms of farm practices to adequately inform the research since all farmers were applying almost similar, methods, practices and technologies for dairy production in Githunguri sub county. Therefore the researcher had to identify another study area (Ruiru) to be to form clusters that would be compared for relationships or differences in dairy production and climate change mitigation practices. This consumed a lot of time. Ruiru was located far from Githunguri and the road connecting Githunguri to Ruiru was undergoing construction and making accessibility difficult.

Only 2 farms were considered for collecting data for calculating the cost of milk production per litre partly because the need to know and therefore to compare the current cost of milk production arose towards the end of data collection. Another reason was limited logistics which could not allow visiting all the interviewed farmers for the second time. Collection of data from a wider sample would have given a more clear indication of the cost of production per litre in the study area.

CHAPTER 4: FINDINGS

4.1 Introduction

This chapter presents findings from the field research. The data presented in this chapter was collected using a mixture of methods including literature search, observation survey and key informant interviews. Qualitative data was processed using computer programs such as SPSS V.25 and Ms. Excel V.10 and results were presented in appropriate tables and figures. Qualitative data was processed and presented in narrative form and where applicable, appropriate tables, figures and models were developed to give a clear analysis as indicated in different sections below.

4.2 Observations

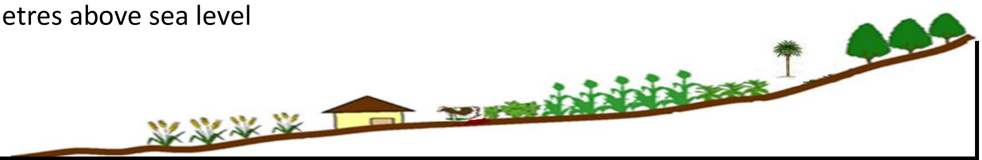
A farm transect walk was conducted on respondents farms, however it was observed that majority of the farms had common features and carried out almost similar dairy production practices. One farm was selected to represent finding from the farm transect walk and observations are presented table 8.

Table 8: Farm transect map in Githunguri Sub county

Name: Peter Kamitha Location: Githunguri ward, Keriko village. Land area: 3 acres

Topographic zone: Lower highland zone Soil type: Red volcanic soil

Altitude: 1600 metres above sea level



	Road	Homestead	Farm land	Natural vegetation
Soil	Murram	Red volcanic soils		
Crops		Beans, maize, Irish potatoes, cabbages	Coffee, tea	
Forages		Maize stovers, potato vines, weeds	Mainly napier, sometimes fodder maize	Shrubs and forest patches
Trees	Some trees along the road	Avocado, Mango, Banana Passion fruits	Grevilia, Eucalyptus	Forest trees
Livestock		Cattle (Friesian), Poultry Pigs		
Water sources		Rain water, Shallow well Community project water Municipal water	Rain water	
Infrastructure	Tarmac-main road, Murram-feeder roads	House, Zero-grazing unit Hydro electricity, Water tank, Chuff cutter		
Challenges	Feeder roads affected during rainy season impacting on transportation of produce	Seasonal variability in rainfall patterns Prolonged drought season Small plots of land limiting agricultural expansion	Less incorporation of fodder trees and other fodder plants	Expansion of homesteads encroaching of farms and forest areas
Opportunities	Good road network	Fertile soils and wide range of climatic conditions	Fertile soils support	Presence of forest cover

	linking farmers to the market	support production of wide range of crops and fodder Availability of water and electricity network supports agricultural production	growth of fodder	contributes to water conservation as well as modification of local climate

4.3 Case study on Githunguri DFCS ltd

Results presented in this section were gathered through different key informant interviews. Narrative and descriptive data was gathered, processed and summarized to give a clear description of the operations and activities of the cooperative as well the cooperative and dairy value chain governance as presented in different section below.

4.3.1 Githunguri Dairy farmer Cooperative Society Ltd

Githunguri Dairy Farmers Cooperative Society was started in 1961 by 31 smallholder dairy farmers with one collection centre. The cooperative is located in Githunguri sub county, Kiambu County 50 Kilometres north of Nairobi City (AFAAS, 2013). The Cooperative was formed as an initiative to help the smallholder dairy farmers of Githunguri Division, to market their milk. The cooperative is considered one of the most successful cooperative in Kenya. Over the years the cooperative increased its membership to currently 24,936 smallholder dairy farmers.

i) Input supply

The society has 58 store outlets spread in the catchment area for the provision of animal feeds, animal health products, dairy farm implements and basic human consumables like sugar, salt, rice, corn flour among others. These items are sold to members either cash or on credit against their produce which is recoverable during monthly milk payments.

ii) Production

All the dairy farmers visited during the research practice zero grazing in structures with concrete floor and iron sheet roofs. Milk production varies per household, with peak milk production per cow varying between 8 to 35 litres of milk per day.

iii) Milk collection and transportation

The cooperative has 82 collection centres and 7 cooling centres spread over the catchment area which is mainly the 5 wards of Githunguri subcounty. Two more cooling centres of capacity 10,000 kg of milk are being set up while the capacity of one of the cooling is undergoing expansion from 5,000 to 8,500kg of milk. The cooperative collects between 200,000 to 300,000 kg of fresh milk per day from its farmer. The cooperative also procures milk from cooperative members outside of Githunguri, these are scattered within Ruiru sub county but majority are from Murera ward. This ward is adjacent to Githunguri subcounty which makes transportation of milk from that area easier. However all farmers from Ruiru have to organize their own means of delivering milk to a collection point which is located within Githunguri sub county from where the cooperative milk vans can pick it up and deliver it to the processing plant. Usually, a pick up van is hired to collect milk from members' homes and deliver it to the central collection point. Each farmer pays 2Kenya shillings per litre of milk delivered to the central collection point. In Githunguri subcounty, the milk collection centres are strategically located within walking distance from members' homes which is on average less than 500 meters. The main means of milk transport to the collection center is on foot with milk cans carried in the wheel barrows or milk trolleys.

At the collection point, milk is tested for quality before being transferred to the 50 litre milk cans for transportation to the processing plant. Usually, simple milk tests such as organoleptic tests, lactometer tests and alcohol test are performed at the collection points. Non-conforming milk is rejected and the respective farmers are notified of the reasons for milk rejection. Most common cases of milk rejection are due to mastitis infected milk. Cases of milk adulteration from farmers are rare however if a farmer is suspected to have adulterated the milk, they are warned and fined 20,000 Kenya shillings. If adulteration is reported for the second time, then the farmer is expelled from the cooperative.

Milk collection is usually carried out twice per day i.e. in the morning from 5am to 9am and in the afternoon from 3pm to 5pm to ensure that all morning and afternoon milk is collected and processed to reduce milk wastage. Typically milk collection at collection centres lasts about 1 hour and milk is transported within the shortest time possible to the cooling centres or directly to the processing plant depending on the route. The cooperative contracts private milk transporters but also owns cold chain mobile milk tanks for transporting milk from cooling centres to the processing plant. Milk prices fluctuate according to seasons ranging between Kenya shillings 35 to 45, however, currently farmers are supplying a litre of fresh milk to the cooperative society at 38 Kenya shillings.

iv) Milk processing, trading and consumption

In 2004, the cooperative commissioned its own milk processing plant to embark on value addition by processing and marketing its own dairy products under the flag ship of Fresha Dairy Products. The cooperative has an installed daily processing capacity of 300,000kg of milk however an average of 230,000kg of milk are processed per day (GDFCS, 2018). The cooperative has strategic partnerships with Brookside and New KCC to supply excess milk beyond the processing capacity but also in cases when there is a breakdown in the processing plant to ensure that farmers' milk is not wasted. The cooperative processes and markets a range of milk products including whole milk (both fresh and long life), yoghurt, ghee, butter, lala (fermented milk) and cream (GDFCS, 2018). These products are packed in pouch packs of 200ml, 500ml,; tetra pack 500ml,; as well as plastic containers of 2lts and 5lts respectively. The cooperative also processes bottled water. The cooperative operates wholesale outlet stores distributed across the country including Kiambu town and Nairobi city. Customers for the Githunguri dairy products include internal customers such as the staff and cooperative members while external customers include consumers, distributors, retail outlets, as well as institutions such as schools and hospitals.

v) Stakeholder analysis in the Githunguri dairy value chain

The Githunguri dairy value chain is able to operate successfully due to support from different stakeholders. A list of stakeholders was generated and presented along with the stakeholder's roles and/or interests in table 9.

Table 9: Githunguri dairy farmer cooperative society limited stakeholder matrix

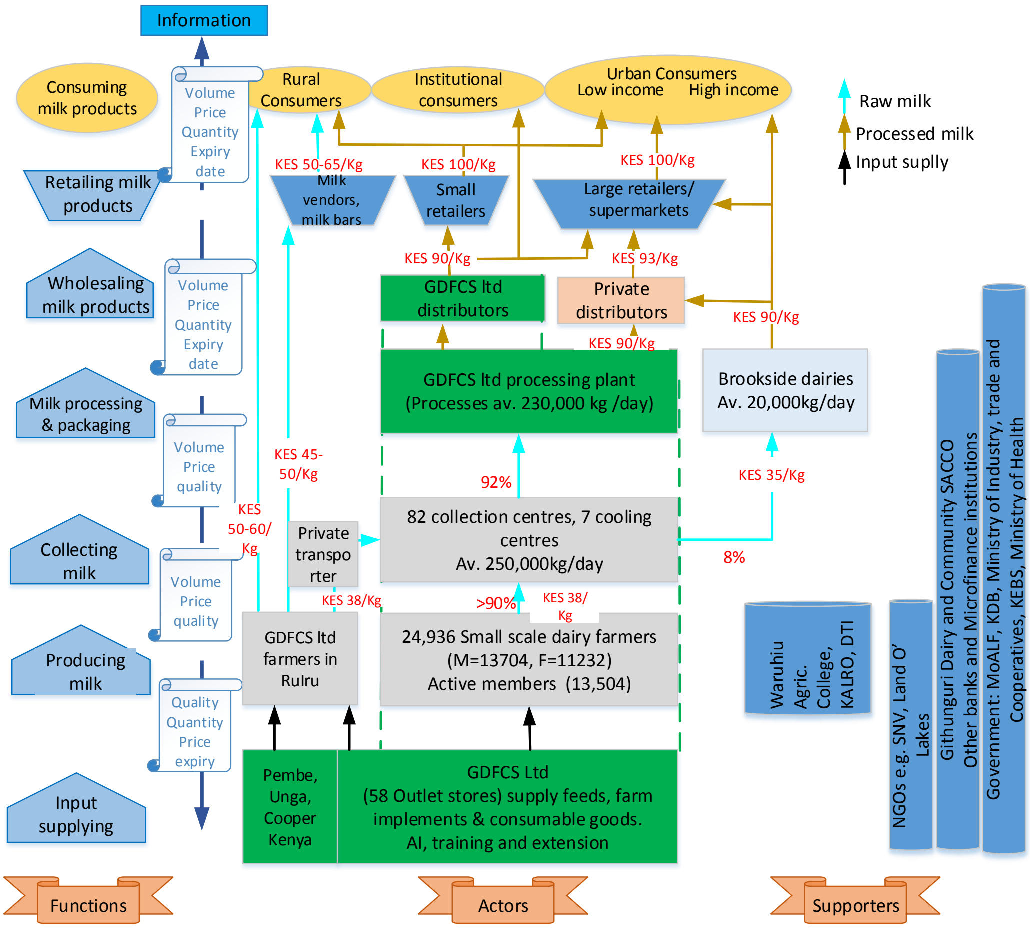
Chain actors	Role(s)/Interest(s)
Input suppliers (Pembe, Unga, Coopers-Kenya)	Supply inputs such as feeds to the cooperative stores
Dairy farmers	Produce milk
Githunguri dairy farmer cooperative society limited	Milk collection, milk processing, and distribution of dairy products
Private milk transporters	Hired on contract basis to deliver milk to the collection centre
Private dairy product distributors	Distribute and wholesale processed dairy products from Fresha factory
Retailers (supermarkets and small shops, milk bars)	These sell milk products to consumers

Consumers (Rural consumers, institutional consumers and urban consumers)	Buy and consume dairy products from Fresha
Chain supporters and influencers	**Role(s)/Interest(s)**
Waruhiu Agricultural College	Train farmers in areas related to animal husbandry, health and feed production
Kenya Agricultural Research Institute Dairy Training Institute-Naivasha	KARI collaborates with cooperative to ensure that milk and dairy products are free from veterinary drugs, residues and disease causing organisms. DTI offers training to farmers
SNV	Train farmers in dairy production practices
Land 'O' Lakes	Trains farmer on feed conservation methods
Githunguri Dairy and Community SACCO	Provides credit and other financial services to dairy farmers
Ministry of Agriculture, Livestock and Fisheries	Provision of extension and advisory services to farmers Involved in livestock disease management (vaccinations)
Ministry of Industry, Trade and Cooperatives	Oversee and trains in cooperative management
Ministry of Health	Provide training in health, nutrition and social wellbeing
County Government	Provision of extension and advisory services to farmers; involved in research and development; coordination of dairy and veterinary activities.
Kenya Agricultural and Livestock Research Organisation (KALRO)	Provision of dairy research services by Dairy Research Institute (DRI)
Kenya Dairy Board (KDB)	KDB is responsible for policies, strategies and regulations governing the quality of milk delivered to processors and consumers.
Kenya Bureau of Standards (KEBS)	Product standardization and certification

vi) The dairy value chain under Githunguri DFCS ltd

Data regarding aspects such as the core functions, actors, product flow, volumes and information flow under Githunguri dairy cooperative was collected, processed and presented in form of a value chain map to give a clear overview of the cooperative as shown in figure 8.

Figure 8:Githunguri DFCS ltd Value chain map

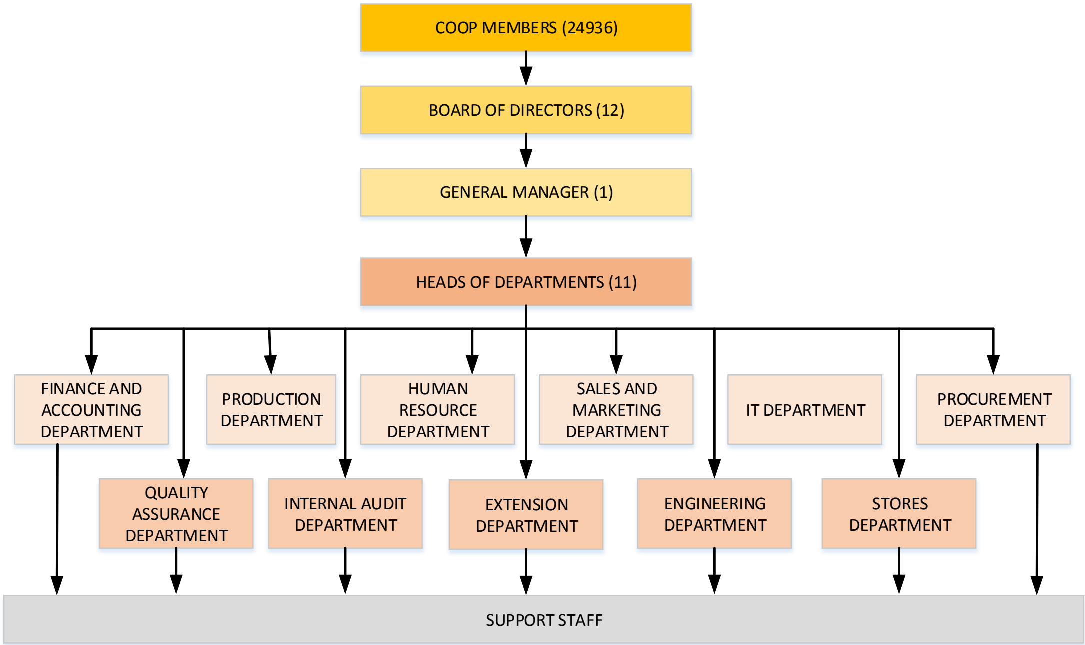


4.3.2 Governance of Githunguri dairy cooperative Society ltd

i) Leadership

Githunguri Dairy Farmer Cooperative Society Ltd is vibrant and operates with a mission " To maximize stakeholders' value by providing high quality brands to the market" and with a vision of ensuring "Real freshness for all". To achieve this, the cooperative is governed by a highly motivated management committee headed by the Board of Directors. The management committee consists of 12 members of which 3 members undertake the supervisory role while 9 members undertake the management role. Daily operations of the cooperative are headed by the general manager. The cooperative is divided into 11 departments (figure 9) to ensure smooth running of its operations. Each department is headed by a head of department who is assisted by an assistant together with supervisors to ensure that daily operations are effected smoothly. The cooperative employs over 300 staff who are committed and motivated to ensure they produce quality results to keep the cooperative highly competitive.

Figure 9: Githunguri DFCS ltd organogram



ii) Core values of the cooperative

The core values of the cooperative include; Self help, Equity, Customer service, Team work, Integrity, Continuous improvement and innovation, Corporate citizenship, Equality.

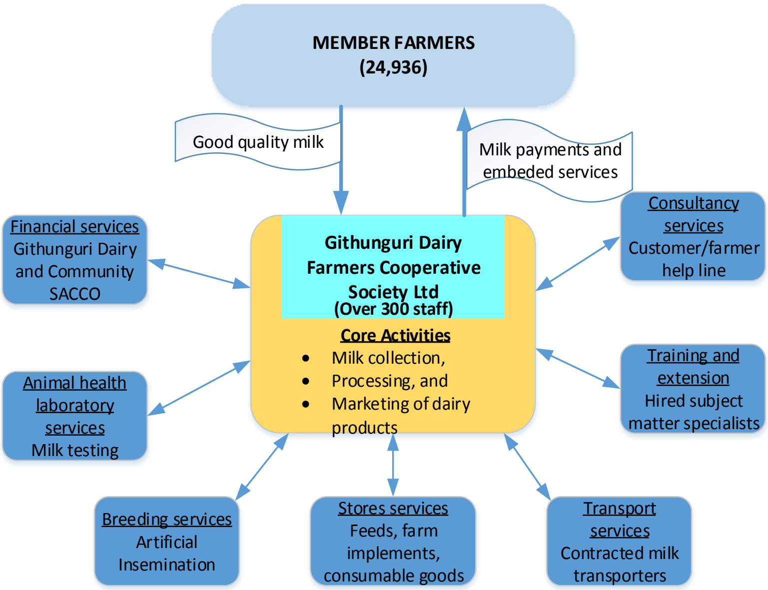
iii) Membership

The cooperative has a total of 24,936 members, however only about 13,500 members are active (those that deliver milk consistently for about 3 months). Of the total membership 52% are male while 48% are female. All members of the cooperative society are shareholders and each member is given an identification card that bears the member's identification number. To be a member, one must be over 18 years of age, should be owning land and should have lactating cows, however membership is currently open only to dairy farmers from Githunguri sub county. Members are clustered according to zones within the catchment area for effective management of the cooperative activities such as monthly trainings and extension, access to stores, as well as milk collection. The zones are subdivided into routes with each route represented by a representative who is a dairy farmer. There are 10 main routes with several sub routes under each main route. Each route are collection centres which are strategically located within a walking distance from the members' homes to ensure timely delivery and collection of milk at the collection points.

iv) Support services

The cooperative operates as a business hub by availing a wide range of inputs and services to smallholder dairy farmers who in turn supply milk to the cooperative as shown in figure 10.

Figure 10: Githunguri DFCS ltd business hub arrangement



Source: Adapted from ILRI Manual (Mutinda et al., 2015)

Stores services: The cooperative provides services such as input supply for feeds, animal health products, farm implements and household consumables like sugar, salt, among others. Stores services are provided on non-profit basis but are managed as cost-centres where each activity and/or store is fully accountable for its expenditure and revenue. Services to members are offered at subsidized prices on cash or credit basis. Payment of services can be effected through cash or checkoff arrangement where members pay for services through deductions from monthly milk payouts.

Extension and training services: The cooperative offers training and extension services to farmers and staff. Currently, the cooperative employs 12 extension officers and each is equipped with a motorcycle. These attend to farmers either on a case by case basis of in groups. The cooperative also seeks services of specialized facilitators (subject matter specialists) depending on the topic to be discussed. Members under every route are entitled to at least one training session per month. Topics to be trained on are agreed upon through consultations and consensus by majority farmers under a given route. Topics so far discussed in July 2018 include modern dairy management practices, financial management, human health and nutrition issues, among others. Facilitators are hired by the cooperative from public and private institutions including ministries such as Ministry of agriculture, livestock and fisheries, Ministry of health and also professional private practitioners.

Breeding and AI services: The cooperative has a dedicated and well equipped breeding and artificial insemination unit with 7 AI technicians each with a vehicle. These respond to farmers' cases either on call or through pre-arranged farm visits.

Milk collection and transport services: The cooperative hires private milk transporters in addition to a chain of cold chain milk transport trucks owned by the cooperative to ensure that all milk produced by farmers is timely transported from the collection centres to the processing plant

IT and Customer services: To ensure proper management and efficient customer service, the cooperatives hires professionals and specialized technical members of staff to offer quality and professional business services. The cooperative uses ultramodern milk processing equipment and has embraced information and communication technology by computerizing most of its operations to ensure smooth service delivery. The cooperative has a website and a 24 hour customer help line to effectively respond to customer queries.

Financial services: The cooperative offers financial and credit services to members through its Savings and Credit Cooperative Organization (SACCO) called Githunguri Dairy and Community SACCO Ltd. The SACCO started in 2003 and members payments for monthly milk delivered are effected to this SACCO to ensure proper management and timely processing and disbursement of members savings and loans.nPackages offered by the SACCO to farmers include: Salary Advance- Availed to all salaried staff; Milk Advance- Available to all Dairy farmers, Jiunge Advance-Given to those who want to join Githunguri dairy Society but do not have the registration fee, Kwamua Advance-Given to members for their emergency need, Mazao Loan- For members who channel their milk through the SACCO, Ngombe Loans - To assist farmers purchase high grade cows for better milk productivity, Biashara Loan-Empowering business community to expand their businesses.

v) Transparency

The cooperative holds annual general meetings in which all members are expected to participate to review past performance of the cooperative, pass resolutions, and also to elect members to vacant positions within the management of the cooperative, among other activities. Other meetings that held include committee meetings as well as joint meetings to review monthly or quarterly performances. Ad hoc meetings are held as and when necessary to address specific tasks and issues that may arise from time to time. During elections as well as on other occasions, officials from the Ministry of Trade, Industry and Cooperatives are invited to witness and ensure that such activities are carried out in a proper way. Farmers under each route as mandated meet at least once every month for extension and training purposes. General information, grievances and consultations are also exchanged/conducted during these meetings. The cooperative also uses mass media communication such as television, radio and newspapers to communicate with members and the general public. The cooperative as well uses telephone calls and 'sms' to reach out to its members. Each member's monthly transactions with the cooperative are communicated through an 'sms' sent directly to the member's telephone contact.

4.3.3 Value chain governance under Githunguri DFCS Ltd

i) Lead actor

The lead actor in the dairy value chain is the Githunguri Dairy Cooperative Society Ltd. The cooperative management board in consultation with farmers through the Annual General Meeting (AGM) sets operating standards which all chain actors are expected to comply with. The cooperative leadership through the different departments work hand in hand with the relevant government and non-government institutions as well as private sector players to ensure that requirements and standards are met. Under each department are different units that are tasked with running of daily activities to ensure that the cooperative meets its targets.

ii) Key parameters

The key parameter involved in running the cooperative such as rules, procedures and standards are set and endorsed by members in the AGM. Personnel under the different Units within departments are responsible for ensuring that the set parameters are observed by the different actors in the chain. The parameters include quality and quantity of inputs, quality of milk produced, standard of milk handling equipment, time of milk collection and delivery, standards for milk processing and packaging, dairy product handling and distribution among others. The cooperative through the stores department ensures that only quality inputs in correct amounts are sourced and supplied to the stores where farmers can access the inputs. Dairy farmers under the cooperative are expected to produce and deliver quality milk to designated milk collection points at agreed times to ensure timely collection and delivery of milk to the processing plant. All farmers are expected to deliver good quality milk to collection centres using recommended containers such as stainless steel milk cans. Milk collection should be done on time and only quality milk should be collected in 50 litre stainless steel milk cans and transported to the processing unit. Usually milk tests are performed at collection points to ensure only milk of desired quality in collected. Tests such as organoleptic tests and alcohol tests are performed to ensure that only milk that meets the desired standards is collected and processed. Along the chain, the cooperative ensures that only quality dairy products in proper packaging and correct quantities are delivered to the customer. The cooperative is also responsible for observing that other actors in the value chain operate according to guidelines set by the government. Table 10 highlights the different key parameter involved in governance the Githunguri dairy value chain.

Table 10: Key parameters in the governance of Githunguri DFCS Ltd dairy value chain

Actor	**Nature of product (s)/service(s)**	**Standard operating procedures (What, when and how much)**
Input suppliers	• Supply quality input products and services	• Should timely supply desired quantities of input products that meet KEBS quality standards.
Dairy farmers	• Produce and supply quality milk	• Should produce and deliver un-adulterated, mastitis free milk to collection points on time using stainless steel milk cans.
Milk graders and milk collectors	• Collect quality milk at a specified time	• Should test, collect and deliver good quality milk within 4 hours from designated collection points to processing plant using recommended equipment.
Processor and packers	• Process and package quality milk products using quality processing and packaging materials	• Should receive and process quality milk products that are highly competitive on the market. • Should ensure that milk processing is done in a secure and clean environment. • Should use appropriate and well labelled packaging materials.
Milk product distributors	• Collect and distribute quality milk products	• Should supply quality un-adulterated milk products to the market in correct packaging and quantities
Retailors	• Store and sell quality dairy products from Fresha	• Should appropriately store and market Fresha dairy products according to guideline information on the packaging materials
Consumers	• Consume quality Fresha dairy products	• Consume quality dairy products from Fresha. • Provide feedback information to Fresha for continuous improvement.

iii) Instruments of governance of the Cooperative

Instruments of governance under Githunguri DFCS ltd include:

Contracts with input suppliers, hired private transported and distributors among others.

Standards for products and processes which are observed through performance of quality checks to ensure conformity with the guidelines set by the (inter)national standards regulatory bodies.

Statutory instruments like by-laws and the constitution to guide and ensure proper management of the cooperative and other operations.

Memorandum of understanding (MoU) to create partnerships between the cooperative and other entities/Organizations to ensure smooth operations.

iv) Types of chain governance under Githunguri DFCS Ltd

There are two types of value chain governance observed under Githunguri dairy farmers cooperative society (Figure 11). These include the market type and the modular type of chain governance.

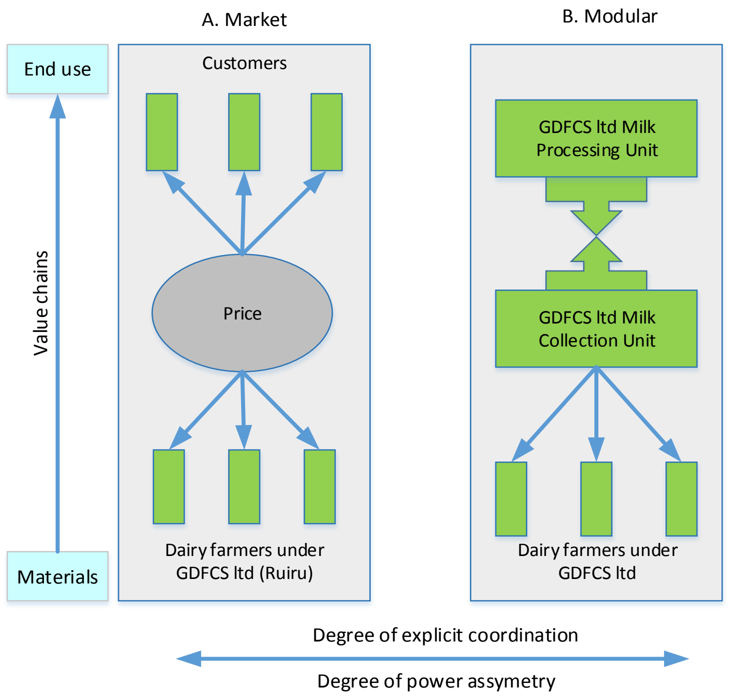
a) Market type of chain governance.

The market type of milk chain governance was observed in Ruiru Sub county where results from the survey indicated that about 50% of respondents sell milk at farm gate through the informal chain. The informal milk chain is mainly cash and volume based where middlemen and milk vendors take the leading role. There is no formal binding agreement between or among actors and the mode of transaction is simply through cash payment for the volume of milk supplied. There is no or less regard for milk quality and information exchange between actors is limited to quantity and price per volume of milk.

b) Modular type of chain governance

In contrast, all interviewed farmers from Githunguri subcounty indicated that they sell all their milk through the cooperative, which in this case is a formal milk value chain. All farmers under the Githunguri DFCS are registered with the cooperative and milk volume supplied by each farmer is measured and registered. Quality tests are conducted on every milk supplied by the farmer to ensure that only milk that meets quality standards desired for processing of different dairy products is collected, non-conforming milk is rejected. In this case, the milk collection and processing units under the production department of the cooperative take the leading role. The cooperative's operations are guided by by-laws and standards which all members have to comply with. Through trainings and extension services, farmers are informed among other things about dairy cattle management and quality milk production and handling to minimize post-harvest losses in form of milk rejections which is a cost not only for farmers but also the cooperative and the environment.

Figure 11: Types of milk chain governance observed under Githunguri DGCS Ltd



Source: Adopted from Gereffi et al., 2005

4.3.4 SWOT/Sustainability of Githunguri DFCS ltd

Through the different key informant interviews, data on the strengths, weaknesses, opportunities and threats was collected and organized in a way to highlight the economic, environmental and social aspects which together represent the sustainability of Githunguri DFCS ltd. The results are presented in table 11.

Table 10: The table presents finding on SWOT analysis/sustainability of the cooperative

	Strength	**Weakness**	**Opportunities**	**Threats**
Economic robustness	• Availability and ease of access to input services through the cooperative • Improved access to market through collective marketing • Value addition through milk collection, processing and marketing • Availability of quality control system • High productive breeds owned by farmers • Check-off payment system ensures farmers' access to financial services at all times	• Milk losses due to diseases like mastitis	• Increasing local population present market for dairy products • Enabling policy environment • Potential to explore regional and internal market • Availability and access to infrastructure such as electricity and water	• High cost of inputs like feeds • Competition from other dairy cooperatives and processors • Consumer preference for raw unprocessed milk • Flooding of the market with cheaper low quality dairy products and other beverages
Environmental robustness	• Crop livestock integration ensures nutrient recycling	• Limited diversification in terms of forages and fodder trees • Limited awareness on CSA practices	• Fertile soils support fodder growth • Promotion of biogas production • Increased support for climate change mitigation	• Disease outbreaks like lumpy skin disease, mastitis undermine milk production • Increased cases of droughts and inconsistent rainfall patterns affecting milk production
Social robustness	• Majority of farmers are educated • Gender empowerment with women fully involved at different levels of the value chain • Availability of extension system to harness production • The cooperative presents employment opportunities • Strong chain coordination • Increased involvement of youth in dairy production	• Small plots of land undermine farm expansion	• Stable political environment • Good land tenure system through land titles • Availability of unemployed youth	• Limited availability of labor • Increasing human population impacting on land availability for livestock production

4.4 Focus group discussions

The information presented in this section is a summary of data that was gathered through discussions with dairy farmers and extension officers under Githunguri DFCS on the different aspects of the research. Findings were summarized and presented under the different sections as indicate below.

4.4.1 Farmer perceptions about climate change in Githunguri

A focus group discussion was held with farmers and discussed among other things their view of what climate change was and in what ways they were able to identify the changes in climate and how these changes affected livestock production. The results of the discussion were noted and presented in table 12.

Table 11: Farmers' perception of climate change

Seasons	Observed changes	Effects on livestock production	
		Animals	Forage and fodder production
Dry season Mid-December January February	• Un usually higher temperatures resulting into dry and hot conditions	• Reduced milk production • Increased water consumption • Inadequate feeding • Heat stress	• Crop failure • Poor quality fodder and pasture • Decreased fodder and pasture yields • High feed prices
Long rainfall season March April May	• Unpredictable rainfall patterns • Inadequate rains	• Reduced water intake • Increased cases of mastitis, pneumonia and foot rot • Higher milk yields	• Increased fodder yields • Low feed prices especially hay
Cold season June July August	• Lower than average cold weather conditions sometimes with frost	• Reduced feed and water intake • Reduced milk production • Increased cases of mastitis and pneumonia	• Poor fodder growth • Low feed prices
Short dry season September Mid-October	• Higher than average temperatures	• Heat stress • Reduced milk production • High water intake	• High feed prices • Low fodder yields • Poor quality fodder
Short rainfall season Mid-October November Mid-December	• Un predictable rainfall patterns • Inadequate rains	• Increased cases of mastitis, pneumonia and foot rot	• Increased fodder production

4.4.2 Current practices contributing to climate smart dairy farming in Githunguri

A focus group discussion was held with the extension officers under Githunguri Cooperative to identify the current practices contributing to climate smart dairy farming. A format developed by the world

Bank and CIAT (2015) to identify climate smart mitigation practices was adapted and applied in this study. The results of the discussion are presented in the table 13.

Table 12: Current practices contributing to climate smart dairy production

Smartness category	Indicators	Climate change mitigation practices identified
1. Water smartness	1.1 Allows reduction in the volume of water consumption per unit of product (food).	1.1.1 Use of high productive dairy cattle breeds
	1.2 Enhances water and moisture retention in soils (mm/m, %).	1.2.1 Mulching, use of cover crops, minimun tillage
	1.3 Promotes protection/ conservation of hydric sources (especially headwaters).	1.3.1 Agroforestry, zero grazing
	1.4 Promotes water capture/ use of rainwater for agricultural production.	1.4.1 Rain water harvesting, irrigation
2. Energy smartness	2.1 Allows for reduced consumption of fossil energy (reflected by savings in fossil fuel combustion, or electric energy consumption [J/kg, J/h, etc.])	2.1.1 Use of milk trolleys/wheel barrows for transporting milk, use of electic driven chuff cutters and water pumps
	2.2 Promotes the use of renewable energy sources (e.g. wind and/or solar energy, biogas, etc.)	2.2.1 Biogas production
3. Carbon smartness	3.1 Increases above- and below-ground biomass (ton/ha; kg/m^2 etc.). This is related to the mitigation pillar in terms of carbon dioxide (CO_2) capture (plant biomass, wood etc.).	3.1.1 Agroforestry, crop rotaition
	3.2 Enhances the accumulation of organic matter in soils (soil carbon stock) (Soil Organic Carbon (SOC) or Soil Organic Matter (SOM).	3.2.1 Mulching
	3.3 Reduces soil disturbance (reflected in number of hours of tractor labor, application of alternative soil management techniques, etc.). Refers to the mitigation pillar in terms of CO^2, reducing carbon emissions (mainly emissions associated with tillage process)	3.3.1 Conservation tillage, use of cover crops
4. Nitrogen smartness	4.1 Reduces the need of synthetic nitrogen-based fertilizers (e.g. kg/ha/year)	4.1.1 Application of manure in crop fields, grass-legume intercropping
	4.2 Reduces nitrous oxide (N_2O) emissions (by adopting better techniques of fertilizers use and soil management practices). Reflected in, for instance, reductions in number of grams of N^2O/m^2/year.	4.2.1 Apply right quantities on fertilizers
5. Weather smartness	5.1 Minimizes negative impacts of climate hazards (such as soil degradation, effects of flood or prolonged drought events among others).	5.1.1 Agroforestry 5.1.2 Seasonal management of cow herd numbers
	5.2 Helps prevent climatic risks (refers to practices that allow farmers be more prepared to mitigate climate risks, such as water reservoirs, early warning	5.2.1 Rain water harvesting and water storage.

		systems, heat/, water stress- pests- and diseases-tolerant/ resistant varieties, etc.)	5.2.2 Zero grazing 5.2.3 Drought resistant fodder plants e.g. napier 5.2.4 Use of irrigation 5.2.5 Hay and silage making
6.	Knowledge smartness	6.1 Allows rescuing or validates local knowledge or traditional techniques (indigenous knowledge)	6.1.1 Mulching, contuor ploughing, crop rotation

Source: Adapted from World Bank and CIAT, 2015.

4.4.3 Gender roles in climate change mitigation under Githunguri DFCS dairy value chain

The focus group discussion held with farmers also discussed about the roles of gender in ensuring climate change mitigation, results were noted, summarized and presented in table 14.

Table 13: Matrix indicating gender roles in mitigation of climate change

Role	Men's major tasks	Women's major tasks
a) Production (On farm)		
Pasture and fodder management	• Make decisions of which fodder plants to grow • Involved in harvesting and transporting of fodder for livestock • Often hired male farm workers provide labor for harvesting and chopping fodder	• Involved in land preparation for cultivation of fodder • Involved in harvesting of fodder
Dairy cattle feeding	• Hired farm workers provide the feeds	• Provide feeds for the animals in absence of male farm workers
Ensuring water availability for livestock	• Involved in setting up of the watering system	• Ensure that livestock regularly have access enough water for drinking
Animal welfare	• Oversee construction and repair of the cow barn • Liaise with vets to ensure animal health	• Ensure the cow barn is clean
Dairy cattle ownership	• Make decisions over which breeds and how many cows to keep	• Have limited decision over cattle ownership
Manure management	• Hired male farm workers collect and transport manure to the field • Involved in feeding the bio-digester	• Involved in collection and transportation of manure • Involved in feeding of the biogas in absence of farm workers
b) Milk collection and transportation		
Milk transportation	• Mostly hired male workers transport milk to the collection centre using bicycles, or on foot with wheel barrow/milk trolley	• Transport milk to collect centre on foot sometimes using wheel barrows/milk trolleys

4.5 Survey

A structured questionnaire was used to gather quantitative data on the different aspects of the research including background information of the households and the respondents, landholding system, forage and fodder management, conservation agricultural practices, dairy animal management and welfare, water resource management and manure management. The interviews were conducted on 48 smallholder dairy farms from two Subcounties including 24 farms from Githunguri sub county and 24 farms from Ruiru sub county. Collected data was processed using appropriate computer programs such as SPSS version 25 and Microsoft Excel version 2010 to generate summaries in form of figures and tables as indicated under the different sections below.

4.5.1 General characteristics of farmers

i) Gender and age of respondents

Majority of respondents in the study were male (58%) while female were 42% as shown in Figure 12. Results from the research also indicated that 80% of the surveyed households were male headed while 20% were female headed. The survey revealed that majority of respondents (67%) were below 50 years of age while 33% were nearing retirement or had already retired from public service. The study also indicated that youths (27%) were actively involved in dairy farming as shown in figure 13.

Figure 12: Gender of respondents

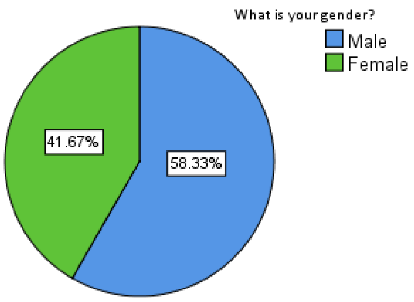
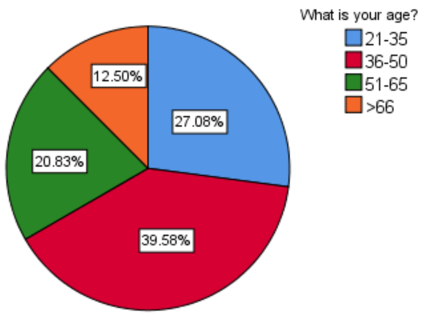


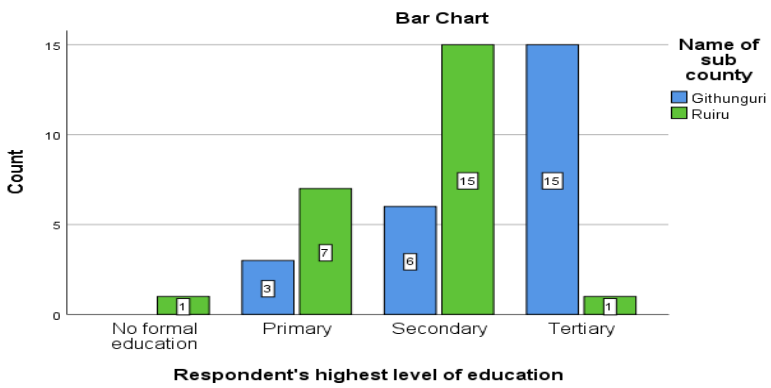
Figure 13: Age of respondents



ii) Level of education

The study revealed that 77% of the respondents (n=37) had attained at least secondary or higher level of education while 33% of respondents (n=11) had primary or no formal education as indicated in figure 14.

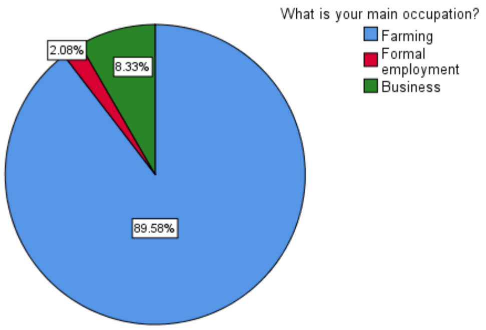
Figure 14: Level of education



iii) Main occupation

The study revealed that majority (90%) of respondents were involved in farming as their main occupation as shown in figure15.

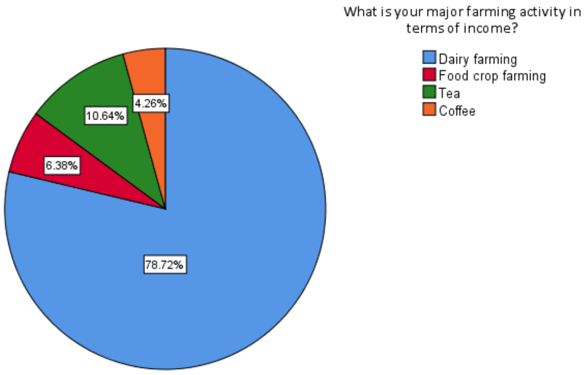
Figure 15: Respondet's main occupation



iv) Major farming activity

Respondents reported that among farming activities, dairy farming (79%) contributed most to their incomes followed by tea (11%) while food crop contributed less at 6% as shown in figure 16. Farmers highlighted that dairy farming (zero grazing) was more profitable and required less land compared to other farming activities. Respondents highlighted that they grew crops such as maize, beans and vegetables mainly for home consumption.

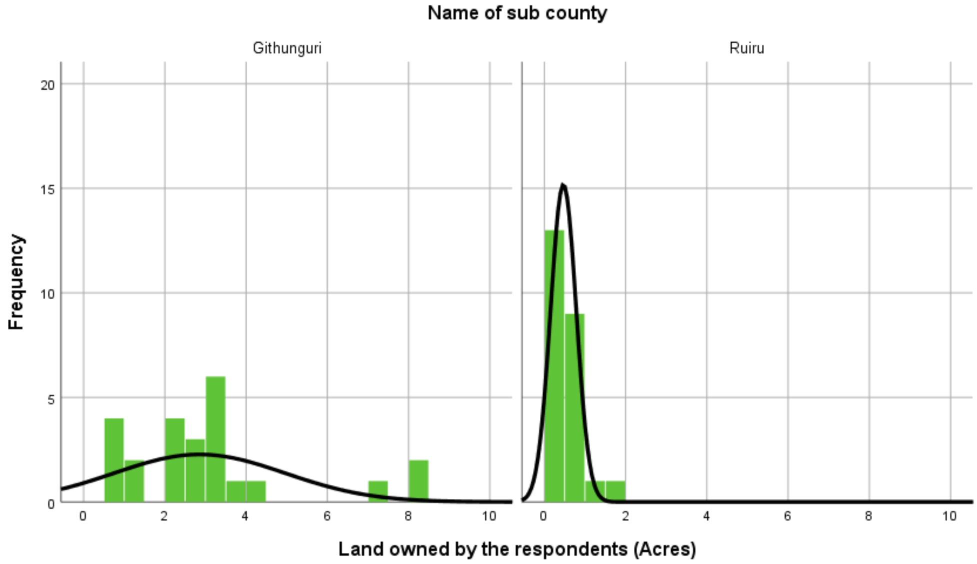
Figure 16: Major farming activity



4.5.2 Land ownership and size of land owned

All respondents in the study (n=48) reported that the land on which they were practicing dairy farming was secured with land titles either privately owned (83%) or through family ownership (17%).The study results indicated that majority of respondents in Githunguri sub county (83%) own less than five acres of land with average land owned equivalent to 2.85 acres (SD 2.107) while majority of respondents in Ruiru sub county (96%) owned less than an acre with average land owned equivalent 0.47 (SD .318) of an acre as sown in figure 17.

Figure 17: Size of land owned by respondents



Overall there was a significant difference at level 5% (independent sample t-test p=.000) in average land allocated for dairy farming between Githunguri and Ruiru sub counties (Annex 2a, b). The research indicated that 56% of respondents rented extra land mainly for growing fodder for their animals.

4.5.3 Conservation agriculture practices, fodder production and dairy cattle feeding

Respondents gave multiple answers on the different parameter such as conservation agriculture practices, fodder production and dairy cattle feeding. The data was organized in excel spread sheet and summaries are presented in table 15.

Table 14: Variables studied in fodder production, conservation agriculture practices and dairy cattle feeding

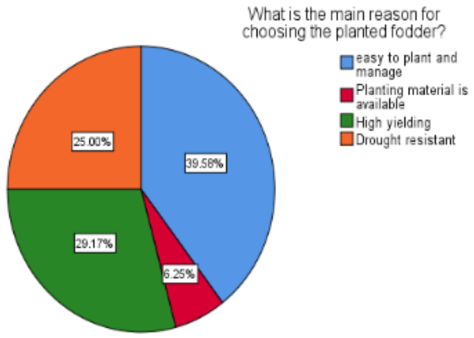
Variables	Overall (n=48)	Githunguri				Ruiru			
	Yes (%)	Yes (n)	%	No (n)	%	Yes (n)	%	No (n)	%
a) Conservation agriculture practices identified									
Crop rotation	95.8	23	95.8	1	4.2	23	95.8	1	4.2
Mixed cropping	85.5	19	79.2	5	20.8	22	91.7	2	8.3
Agroforestry	83.4	21	87.5	3	12.5	19	79.2	5	20.8
Mulching	89.6	22	91.7	2	8.3	21	87.5	3	12.5
Terracing	12.5	5	20.8	19	79.2	1	4.2	23	95.8
Manuring	95.9	24	100	0	0.0	22	91.7	2	8.3
b) Types of improved fodder planted									
Napier	100	24	100	0	0.0	24	100	0	0.0
Desmodium	12.5	5	20.8	19	79.2	1	4.2	23	95.8
Kikuyu grass	2.1	0	0.0	24	100	1	4.2	23	95.8
Lucerne	12.5	2	8.3	22	91.7	1	4.2	23	92.8

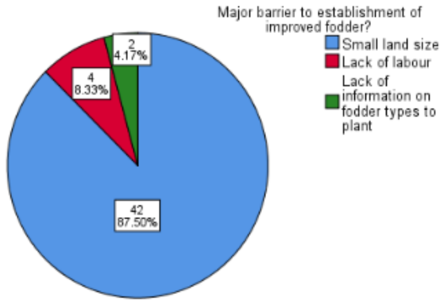
Fodder maize	14.6	4	16.7	20	83.3	3	12.5	21	87.5
c) Fodder trees planted									
Calliandra	8.4	4	16.7	20	83.3	0	0.0	24	100
Grevillia	83.4	21	87.5	3	12.5	19	79.2	5	20.8
d) Feeds and concentrates given to dairy cattle									
Napier	100	24	100	0	0.0	24	100	0	0.0
Maize stovers	89.6	19	79.2	5	20.8	24	100	0	0.0
Hay	95.6	24	100	0	0.0	21	91.7	2	8.3
Silage	10.4	2	8.3	22	91.7	3	12.5	21	87.5
Fodder maize	14.6	4	16.7	20	83.3	3	12.5	21	87.5
Pineapple pulp	16.7	7	29.2	17	70.8	1	4.2	23	95.8
Brewers waste	22.9	9	37.5	15	62.5	2	8.3	22	91.7
Dairy meal	97.9	24	100	0	0.0	23	95.8	1	4.2
Wheat bran	95.9	24	100	0	0.0	22	91.7	2	8.3
Maize germ	54.2	11	45.8	13	54.2	15	62.5	9	37.5
Pollard	16.7	5	20.8	19	79.2	3	12.5	21	87.5
Mineral supplements	100	24	100	0	0.0	24	100	0	0.0

Table 17 presents summaries of different variables that were studied during the survey which include information on planted fodder, conservation agricultural practices as well as feeds and concentrates used in dairy production. All respondents (n=48) reported that they had planted improved fodder of which napier grass was the most grown (100%) in the study area. 15% of respondents indicated that they planted maize specifically for feeding to cattle while other fodder plants mentioned by respondents included Desmodium (13%), Lucerne (13%) and Kikuyu grass(2%). Overall, respondents reported that the main reason for planting napier (Figure 18) was because it is easy to plant and manage (40%), followed high yielding (29%), drought resistant (25%) and lastly availability of planting materials (6%). The major barrier to incorporation of other fodder plants on the farm (Figure 19) as reported by respondents was that they owned small plots of land (88%) yet they needed constant feed supply throughout the year. Other barriers to fodder establishment as mentioned by respondent included lack of labor (8%) and lack of information on fodder production (4.17%).

The most planted fodder tree as reported by respondents was grevillia (83%) although most respondents indicated that they use it as a source of firewood and timber as opposed to fodder. Over 85% of respondents reported to carryout conservation agriculture practices such as crop rotation, mixed cropping, agroforestry, mulching and addition of manure to crop and fodder plots. Over 85% of respondents reported that they used napier, maize stovers, and hay to feed their dairy cattle. Less than 20% of respondents reported to have used silage, fodder maize, pineapple pulp and brewers waste to feed their animals. In terms of concentrates feeding for dairy cattle, over 90% of respondents indicated that they used dairy meal and wheat bran to boost milk yield while 54% and 17% reported to use maize germ and pollard to boost production. All respondents (100%) reported to use mineral supplements health and productivity of their dairy cattle.

Figure 18: Main reason for choice of fodder   Figure 19: Barriers to fodder establishment

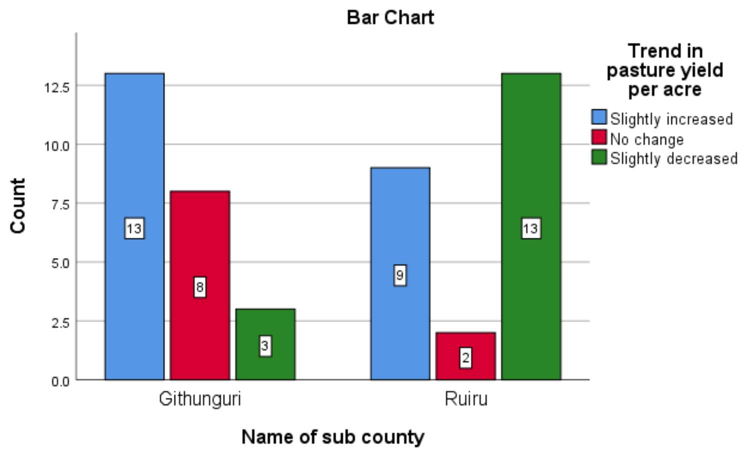




e) Trends in fodder yields per acre

Majority of respondents (54%) in Githunguri sub county reported that there was a slight increase in yields per acre in the last 10 years attributing the increase to replenishing of the fodder fields with manure from cattle sheds while 33% and 13% indicated that was either no change or there was a slight decesase in fodder yiels per acre as shown in figure 20. In Ruiru sub county, majority of respondents (54%) reported that there was a slight decrease in fodder yields, the decrease was attributed to unreliable rainfall (42%) as well as poor soil fertility (38%).

Figure 20: Trends in fodder yield per acre.



f) Fodder availability in the different seasons

Overall, 85% of respondents reported that they had adequate fodder for the animals in the wet season while 15% reported to have a shortage in fodder supply in the wet season (Figure 21). Conversely in the dry season, majority of respondents (75%) indicated that they experienced fodder shortage (Figure 22) which highlighted the need for respondents to engage in fodder conservation practices like hay and silage making.

Figure 21: Fodder supply in wet season

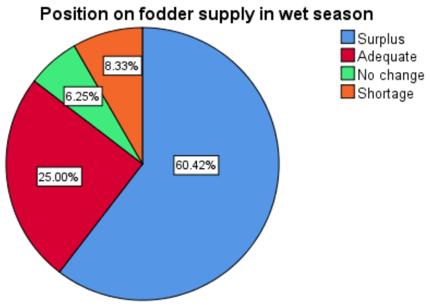
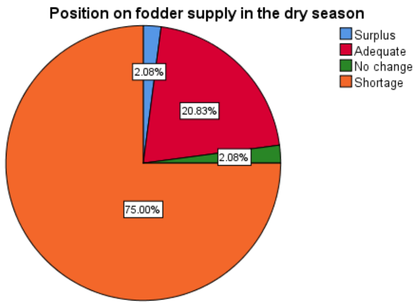


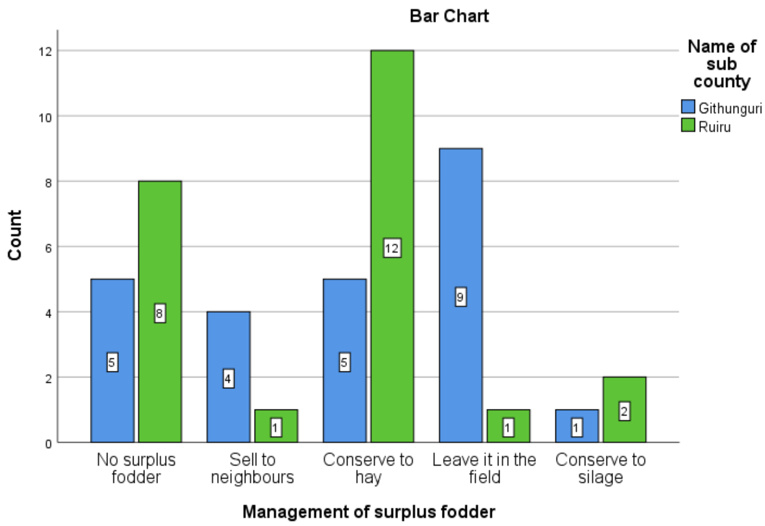
Figure 22: Fodder supply in dry season



g) Management of surplus fodder

Majority of respondents (47%) with surplus fodder in Githunguri sub county indicated that they left it to grow in the gardens while 31% indicated that they conserved either into hay (26%) or silage (5%). 21% of respondents in Githunguri indicated that they sell excess fodder to the neighbors. Majority of respondents (71%) in Ruiru indicated that they conserve excess fodder into hay mainly in form of standing hay, 18% conserved excess fodder in form of silage fodder while 5% sold excess fodder as shown in Figure 23.

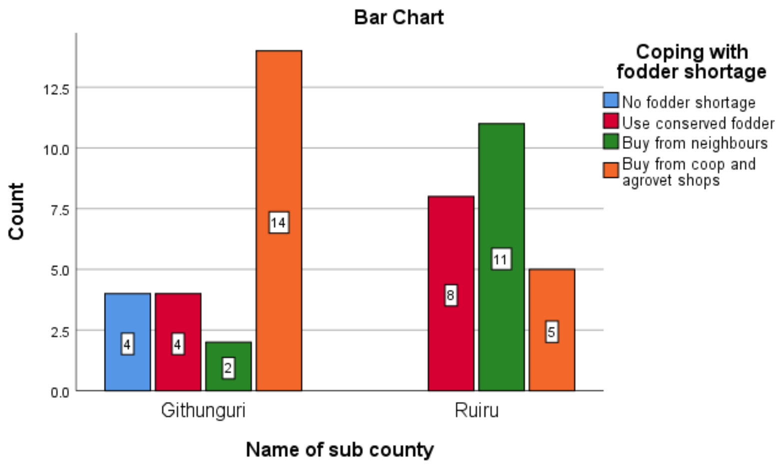
Figure 23: Management of surplus fodder



h) Coping with fodder shortage

In times of fodder scarcity, majority of respondents (70%) in Githunguri Subcounty indicated that they bought feed from the cooperative stores and agrovet shops which are scattered across the subcounty (Figure 24). Respondents also highlighted that feeds supplied through the cooperative stores were of good quality as compared to those bought in other agrovet shops. In Ruiru Subcounty, respondents indicated that they use conserved fodder (33%) and supplement it with buying extra fodder from their neighbors (46%) mainly those not involved in dairy farming indicating the role of dairy farming in creating market for locally produced fodder in the area.

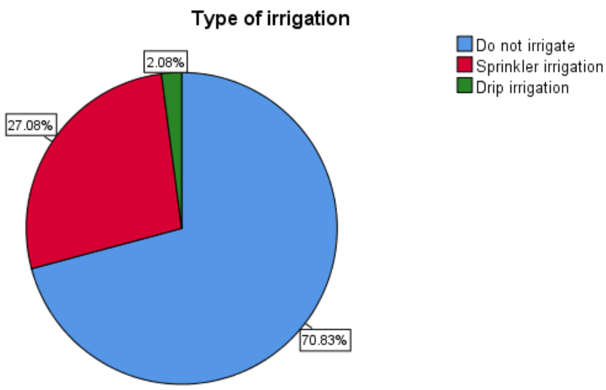
Figure 24: Coping with fodder shortage



i) Irrigation of pastures

Overall, 29% of the respondents indicated that they carried out irrigation to enhance fodder production in the dry season as shown in Figure 25.

Figure 25: Adoption of irrigation



4.5.4 Dairy cattle management

i) Dairy production system and herd management

All respondents (n=48) in the survey reported that they kept their dairy cattle under the stall feeding (zero grazing) system of dairy production. The study revealed that all respondents (n=48) kept improved dairy cattle breeds such as Friesians, Ayrshire, Holstein, and Friesian crosses. The main reason for dairy farming as reported by respondents was that it was a source of income (73%), other reasons included source of food (19%), for manure(4%) and hobby (4%).

Figure 26: Type of breeds kept

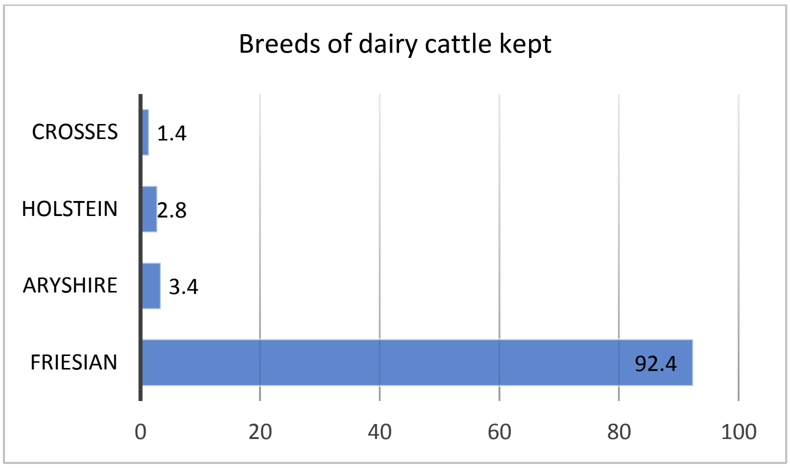


Figure 26 shows that Friesians made up majority (92%) of the dairy cattle population compared to other breeds including Ayrshire (3%), Holstein (3%) and Friesian crosses (1%). All respondents (n=48) in the survey reported that they were able to maintain or improve their cattle breeds through use of artificial insemination which was readily available through the Cooperative. Respondents indicated that preference for Friesian cattle was due to its high productivity and resistance to diseases compare to other breeds which were prone to cattle diseases. Respondents also reported that silent heat was a common factor that resulted to poor heat detection contributing to irregularities in calving intervals.

Majority of respondents in Githunguri subcounty reported that mastitis (96%) and pneumonia (71%) were the most common diseases encountered in the past 12 months. Respondents indicated that both diseases were common in the wet and cold seasons. In Ruiru sub county, 50% of respondents reported to have encountered lumpy skin disease while 13% reported to have encountered East Coast Fever in the past 12 months. Respondents highlighted that Lumpy skin disease contributed to major cattle deaths in the area.

Table 15: Dairy herd structure

Dairy herd	Overall	Githunguri		Ruiru	
	%	Count	%	Count	%
Cows in milk	53.1	119	54.3	41	51.9
Dry cows	13.4	31	14.2	10	12.7
Heifers	13.6	29	13.2	11	13.9
Female calves	16.2	35	16.0	13	16.5
Male calves	3.7	5	2.3	4	5.1
Total	100.0	219	100.0	79	100.0

Results from the study (Table 16) indicated that lactating cows made up majority (67%) of the herd structure followed by female calves (16%). Respondents highlighted that female calves were kept mainly for replacement purposes while majority of male calves were sold off at below 1 year of age to reduce on cost of feeding and maintenance.

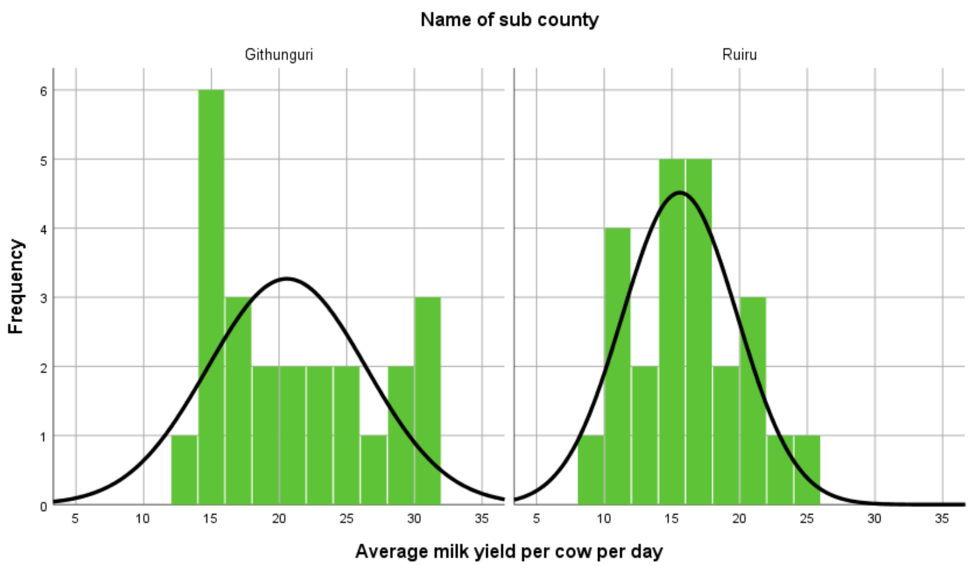
ii) Total number of cattle kept and number of milking cows

The total number of cattle kept as reported by respondents in Githunguri sub county (n=24) ranged from 3 to 15 heads of cattle with farmers keeping an average of 9 (SD 4.26) while respondents in Ruiru sub county (n=24) reported that they kept a total number of cattle ranging from 1 to 8 heads at an average of 3 (SD 1.459) (Annex 4). The average number of cows in milk in Githunguri was 5 (SD 3.029) while the average number of cows in milk in Ruiru was 2 (SD .859) (Annex 4). Respondents indicated that they were able to maintain a certain number of cattle on their farms through culling off of the adult and less productive cattle as well as through selling off of all male calves.

iii) Milk production

Results indicated that there was a normal distribution in milk production in Githunguri and Ruiru sub counties (Figure 27). An Independent sample t-test to compare the mean of milk production between Githunguri and Ruiru sub counties indicated that the average milk yield in Githunguri sub county was 21 (SD 5.86) while the average milk yield in Ruiru sub county was 16 (SD 4.24). The test indicated that there was a significant difference at 5% level (independent sample t-test p=.002) in the average milk yield per cow per day between Githunguri and Ruiru sub counties (Annex 5).

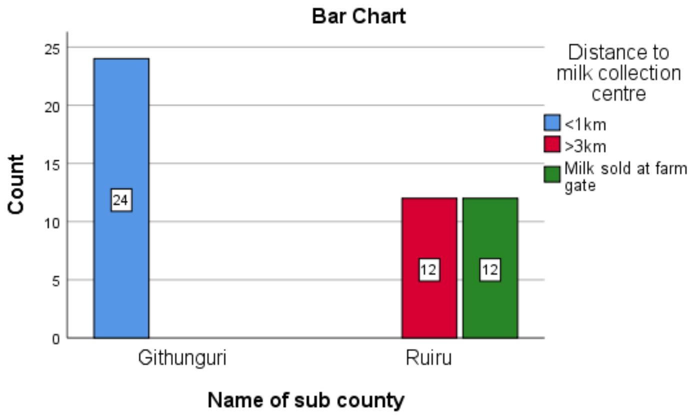
Figure 27: Average milk yield per cow



iv) Distance to milk collection centre

Results from the study indicated that all respondents (100%) in Githunguri subcounty (n=24) had milk collection centres located in less than 1 kilometer from their homes while 50% of respondents in Ruiru sub county (n=12) had the milk collection centre located over 3 kilometers from their homes (Figure 28). By the time the research was conducted, 50% of respondents from Ruiru subcounty (n=12) reported that they were not delivering milk to the cooperative and as such were selling it at farm gate mainly to neighbors. The reason given for not delivering milk was they kept very few animals and produce less milk yet the cost of transporting milk to the collection centre was high.

Figure 28: Distance to milk collection centres

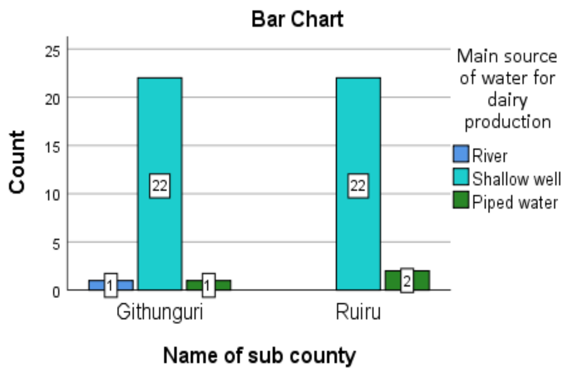


In terms of transporting milk to collection centres, the study revealed that 79% of respondents in Githunguri sub county (n=19) used emission free means (50% walk on foot sometimes carrying milk cans in wheel barrows or milk trolleys, 19% use bicycles) to deliver milk while 21% of respondents (n=5) used motorcycle (17%) and milk van (4%). In Ruiru subcounty, all respondents (n=12) that deliver milk to collection centres (50%) hire a milk van which transports milk to a collection centre located in Githunguri sub county which was over 3km from farmers' homes. The respondents highlighted that the cost of hiring a milk van was high however they considered the embedded benefits of being an active member of the cooperative society.

4.5.5 Main source of water for dairy cattle

The study indicated that majority of respondents (92%) in each sub county were using shallow well water for dairy production as shown in Figure 29. Other sources of water for dairy production included river and piped water supplied by the local government. Overall, 96% of respondents in Githunguri and Ruiru sub counties indicated that that water source was located within the farm compound while only 4% reported that the water source was located less than a kilometer away from the farm. This ensured that animal had access to water all the time as reported by all the respondents.

Figure 29: Main source of water for dairy production

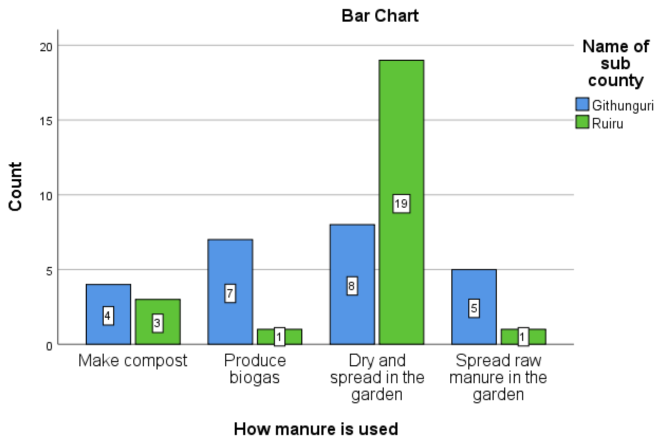


Majority of respondents (over 75%) with shallow wells in Githunguri sub county and in Ruiru sub county reported that they had submersible water pumps which run on electricity. These water pumps are durable and emission free while 17% of respondents with shallow wells in Ruiru indicated that they drew water manually using and open jerrycan tied on a rope.

4.5.6 Manure use management

All respondents in the study (n=48) indicated that they collected manure from cow sheds and used it in different ways as shown in figure 30. Majority of respondents in Githunguri sub county (86%) and Ruiru sub county (79%) had animal sheds with concrete floor which facilitated ease of manure collection.

Figure 30: Different uses of manure



Majority of respondents in Githunguri (33%) and Ruiru (79%) sub counties indicated that they dried the manure before applying it in the garden. However manure drying was done in the open just besides the cattle shade or by the roadside. Respondents indicated that raw manure was heavy and cumbersome to carry to the field and therefore needed to be dried in an accessible place before carrying it to the field. 13% of respondents indicated that they apply fresh manure from the cow shed into the garden. Overall, the study revealed low adoption of climate smart practices in manure management at including manure composting (15%) and biogas production (17%).

4.6 Case studies on the current cost of milk production per litre on selected farms

The data presented in this section was collected through case studies on two farms, one in Githunguri and another in Ruiru. Data was processed in Excel spreadsheet to give an indication for the cost of milk production per litre in the 2 sub counties as indicated in table 17.

Table 16: Cost of milk production per litre

COST INDICATION PER LITRE OF MILK (Kshs)		
	Githunguri (1 Farm)	**Ruiru (1 Farm)**
ANNUAL VARIABLE COSTS		
Forage;		
Maize stovers	0	24,000
Napier	96,000	12,000
Hay	0	36,000
Concentrate;		
Dairy meal	204,000	50,400
Maize bran	0	19,200
Maize germ	0	24,000
Brewers spent grain	240,000	0
Minerals	35,040	14,400
Minerals lick (powder)	31,200	0
Loan interest	0	11,000
TOTAL ANNUAL VARIABLE COSTS	**606,240**	**191,000**
ANNUAL FIXED COSTS		
Health costs	19,800	4,800
Labour	100,800	7,200
Breeding	7,500	2,500
Transport (fuel)	30,000	17,112
Energy cost	3,600	250
Water	3,528	1,143
Telephone calls and internet	1,200	0
Maintenance costs	1,100	0
Depreciation-Dairy barn	10,000	6,000
Depreciation-Equipment	6,140	6,000
TOTAL ANNUAL FIXED COSTS	**183,668**	**45,005**
TOTAL GROSS COSTS	**789,908**	**236,005**
Less side revenues;		
Sale of calves, heifers, adult cows	**2,000**	**40,000**
NET COSTS	787,908	196,005
TOTAL MILK PRODUCTION IN LITRES	29,220	9,864
COST PRICE PER LITRE OF MILK	**27.03**	**23.93**

Foreign Exchange Rate: 1Euro=116 Kenya Shillings. Source: Central Bank of Kenya, July 2018.

Results in the table indicate that the cost of milk production per litre is 27 Kenya shillings while in Ruiru the cost of milk production per litre is 24 Kenya shilling.

CHAPTER 5: DISCUSSION

This chapter builds on the previous chapters and presents a discussion of findings as well as comparing results of the research with existing literature done by other researchers on the similar areas of focus.

5.1 Transect observations

Results of observations made during farm transect walks indicated that the most common food crops grown in the study area were beans, maize, Irish potatoes, vegetable of different types such as cabbages, carrots as well as cash crops such as coffee and tea. In terms of trees, grevillia was the most common type of tree observed almost on every farm, fruits trees such as avocado and mango were also a common sight. These observations are in line with the study made by Staal et al., (1997) in Kiambu district which identified similar crops and trees on smallholder farms, which also indicates the agro ecological potential of the area. Also to note is that majority of farmers grew napier and kept exotic cattle like Friesian cattle under zero grazing units and equipment such as electric driven chuff cutters for feed processing were a common sight on farms further highlighting the level of intensification of dairy farming which Staal et al., (1997) attributes to small land holding in the area.

5.2 The governance of the Githunguri DFCS dairy value chain

Githunguri Dairy Farmers Cooperative society Ltd is a smallholder farmer owned dairy cooperative. The cooperative sources its milk mainly from dairy farmers Githunguri sub county however there are also members in Ruiru sub county who supply milk to the cooperative. According to KIT et al., (2006), a value chain consist of different actors involved in in the different activities along the chain and that actors actively seek to support each other to increase efficiency and competitiveness of the chain. This holds true for the dairy value chain under Githunguri DFCS which is characterised by a number of activities (functions) such as input supplying, producing milk, milk collection and transportation, milk processing and packaging, wholesaling, retailing and consuming, with actors and supporters at different levels of the chain. However, through research it was noted that the cooperative is involved in more than one activity in the chain including input supplying, milk collection and transportation, dairy product processing and marketing, a term collectively known as vertical integration in the value chain (KIT et al. , 2006). According to Mutara et al., (2016), vertical integration leads to high gross margins, influences choices of marketing channel and improves market participation, encouraging commercialisation of dairy smallholder farming which is also true for smallholder dairy farmers under Githunguri DFCS. Research indicated that the cooperative collects and processes an average of 230,000kg of milk per day and had an annual turnover of 6 billion Kenya shilling (GDFCS, 2018) and its mission is to maximise stakeholders' value by providing high quality dairy brands to the market.

The cooperative enlists support from other organisations and institutions including government and private sector as indicated in the chain map (Figure 8). The cooperative hire experts to offer training and extension services to its members on different topics as desired by farmers however it was noted that no training had previously conducted regarding climate change mitigation. This was further evidenced when none of the interviewed personnel from the cooperative knew what climate change mitigation or climate smart agriculture meant. However, it was observed that the cooperative contributes to climate change mitigation and climate smart agriculture in a number of ways. For example, in Githunguri sub county all milk collection centres are located within a walking distance (average of about 0.5km) from the farmers' homes of which majority of farmers (69%) reported that they either walk sometimes carrying milk cans in milk trolleys or use bicycles to deliver their milk, such means of transport are emission free. The cooperative has a dairy processing plant in Githunguri town and over 6 milk cooling centres distributed across the sub county to reduce post-harvest losses related to milk spoilage caused by delayed chilling. Normally fresh milk has to be chilled to less than 4^0C within 4 hours of milking to inhibit microbiological build which leads to milk spoilage. According to FAO (2017b), reduction in postharvest food wastage has a significant impact on curbing global GHG emissions. The cooperative also organises and/or participates in corporate social responsibilities such as tree planting which directly contributes to climate change mitigation.

In term of chain governance, the research identified two types of value chain governance including the market and modular type. Gereffi et al., (2005) notes that the market type of chain governance is characterised by “arms-length” relationship and that transactions in such type of governance require little or no formal cooperation between participants, he also notes that the cost of switching to new partners is low for both the producer and the buyer which is true for the 50% of the smallholder farmers in Ruiru subcounty who according to the research indicated that they sell raw milk at farm gate to their neighbors with no formal agreements. On the other hand, the modular type of chain governance was observed in Githunguri sub county where all farmers in the survey indicated that they sell all their milk through the cooperative. Farmers supplying milk to the cooperative are bound by bylaws of the cooperative to supply milk that meets the quality standards set by the cooperative and as such milk found to be adulterated or that has mastitis is rejected and the farmer is penalized if the vice persists. This is also true according to Gereffi et al., (2005) who highlights that in modular type of chain governance, the producers must make products or provide services according to the buyers specifications. Smallholder farmers are involved in the governance of the cooperative and are the highest decision makers of the cooperative through the annual general meeting, which is described by KIT et al., (2006) as horizontal integration in the chain. In terms of gender inclusiveness, the cooperative is an equal opportunity employers and staff (both male and female) are employed on merit regardless of gender or social status. The cooperative has a total membership of 24,936 of which 13,704 are male and 11,232 are female which denotes a ratio of 1:1 in terms of membership.

5.3 Farmer perceptions of climate change

Through a focus group discussion with smallholder farmers as well as during the survey, the research established what perceptions farmers had about climate change. Worth to note is that majority of farmers (over 85%) indicated that they did not know what climate change was, however, they were able to identify cases associated with the changes in climate which they had observed over the years. Kasulo et al., (2013), urges that understanding of perceptions of rural farming communities towards climate change is important in addressing social vulnerabilities and adaptation/mitigation of climate change. He notes that for farmers to decide whether to adopt a particular measure, they must first perceive that climate change has actually occurred.

Farmers reported that they were able to identify changes in climate through observed changes in temperature and rainfall patterns in the different seasons as well as how these changes impacted on livestock production. In the rainy seasons which are mainly from March to May (long rains) and Mid-October to December (short rains), farmers reported that at least for the past five years, the rainfall patterns had changed and were characterised by inadequate rains than they received in past. Farmers reported that this affected livestock production through prevalence of animal diseases such as mastitis, pneumonia and foot rot. In terms of feed availability especially Githunguri area, farmers indicated that the change in rain fall patterns did not have a big impact of feed production whereas farmers in Ruiru area reported that there was a gradual decline in feed availability even in the rainy season. Farmers in Githunguri area reported that they experienced a cold season between June and August which they said not only increased cases of mastitis and pneumonia but also led to poor feed intake resulting into low milk yields. During the dry season (Jan-Feb, Sep-Mid Oct), farmers reported that they experienced higher than average temperatures in the past five years which was observed through reduced milk yields associated with insufficient feeds for cattle. In terms of fodder availability, majority of farmers reported that they experienced fodder shortages which resulted into increased demand and high prices for hay. Some farmers in Ruiru subcounty indicated that some of their wells dry up resulting into water shortage for livestock hence reduced milk production. Farmers' observation were supported by Press Release Reports from the Kenya Meteorological Department

(2017) which generally indicated delayed onset of rainfall seasons as well as depressed rainfall recorded over most parts of the country. Such scenarios according to meteorological reports resulted into severe drought associated with crop failure, lack of forages and pastures for livestock, and a reduction in water resources for livestock and home consumption.

5.4 Climate smart practices identified in the study area

Although terms like Climate Change and Climate Smart Agriculture were new to respondents, results from the focus group discussions and the survey indicated that farmers in Githunguri and Ruiru sub counties were already carrying out practices that contribute to climate smartness. Identification of climate smart practices in the study area was supported by use of a matrix developed by World Bank and CIAT (2015) to identify country specific baselines on climate smart agriculture (Table 13). The matrix involved use of categories of indicators as well as sub indicators related to the management and use of carbon, nitrogen, energy, weather, water and knowledge, using a set of proxies for each to evaluate climate-smartness. Most of the identified practices were similar in both sub counties and are discussed under the different climate smartness categories below.

i) Water smartness

Under the water smartness category, practices such as use of high productive dairy breeds, manure composting and biogas production, mulching and use of cover crops, zero grazing as well as rain water harvesting were identified to contribute to climate smart dairy farming in different ways. In terms of reduction in the volume of water consumed per unit of product (milk), Lardy et al., (2008) highlights that water consumption in dairy cattle is influenced by a number of factors including feed intake and diet, ambient temperature of the environment as well as physiological status of the animal, however, Ouma et al., (2007) urges that improved dairy breeds are efficient feed convertors and produce on average 6-times as much milk per year than zebu cattle in Kenya. Misselbrook et al., (2013) highlights that covering of manure through composting and biogas production reduces chances of surface and ground water contamination through diffuse water pollution. According to (Duveskog, 2003), practices such as mulching, use of cover crops, minimum tillage, agroforestry as well as rain water harvesting and use for irrigation contribute to enhancement in water and moisture retention in the soil, promote protection of hydric waters, promote water capture and use for agricultural production respectively which contributes to climate smart agriculture.

ii) Energy smartness

Practices such as use of emission free means to transport milk to collection centres through walking, use of milk trolleys/wheel barrows and bicycles as well use of electric driven chuff cutters and water pumps as practiced by majority of farmers in the research area contributes to energy smartness. According to Flysjo (2012), the production and use of biogas for cooking and lighting not only captures methane emissions but also reduces fossil fuel use in households.

iii) Carbon smartness

Practices such as agroforestry, mulching, conservation tillage, and use of cover crops like sweet potatoes were identified to contribute to increase in above and below ground biomass, enhance accumulation of organic matter in the soil as well as reduce soil disturbance. Similar practices were identified by Rojas et al., (2017) to contribute to carbon smartness through carbon sequestration as well as soil organic carbon restoration.

iv) Nitrogen smartness

Practices such as application of manure and bio-slurry on crop and fodder field as well as intercropping were identified and considered to contribute to reduced need for synthetic nitrogen based fertilizers. Similar practices were identified by Denef et al., (2011) to contribute to nitrogen smartness through reduced nitrous oxide emissions. Dickie et al., (2014), urges that need for supplementary nitrogen in the soil is reduced through nitrogen fixation by rhizobium bacteria found in nodules of leguminous plants. Practices such as proper application of synthetic fertilizers in rightful amounts that can easily be absorbed by plants would contribute to reduced nitrous oxide emissions. Farmers indicated that use of synthetic fertilizer was declining as adoption and use of manure was on the rise as reported by 52% of respondents in the survey.

v) Weather smartness

Practicing agroforestry was identified to contribute to modification of the local environment. Practices such as rain water harvesting and storage, zero grazing, use of high productive and drought resistant fodder plants like napier, use of irrigation as well as feed conservation through hay and silage making were identified to allow farmers to be more prepared to mitigate climate change risks.

vi) Knowledge smartness

Practices such as mulching, crop rotation, intercropping as well as bush farrowing among others were identified to have been practiced by farmers since time immemorial and such traditional techniques have in a long time contributed to restoration of ecosystems, hence knowledge and incorporation of such practice in livestock production would contribute to increased resilience climate change.

5.5 Role of gender in climate change mitigation in the Githunguri DFCS value chain

Results from the focus group discussion indicated there was disproportionate distribution in activities carried out by male and female that contribute to climate change mitigation. Participants alluded that in household where there were no hired male farmers workers, it is the women who did majority of the daily chores in the livestock units. Kristjanson et al., (2010), reports that in sub Saharan, women's roles in crop and livestock production are strongly determined by gender and cultural norms. From the discussions, participants reported that women were more involved in activities such as preparation of land to establish pastures as well as weeding, harvesting fodder, providing feeds and ensuring cows had water, cleaning the cow barn and manure collection as well transporting of milk to the collection centres. This was also reported by Ayoade et al., (2009) wo heighted that in Nigeria women feed and manage vulnerable animals, cleaned cow barns and also milk and market milk products. In Ethiopian highlands Yisehak (2008) reports that women were involved in similar activities such as cutting grass and supervising feeding of animals as well as cleaning of cow sheds.

On the other hand, it was reported that men were responsible for making important decisions such as what types fodder to plant, the of breeds to keep, setting up of water and housing structure for the cows as well as liaising with veterinarian in cases when animals had ill health. Njuki et al., (2011) highlights that men are more involved in activities that are carried out weekly or seasonally such as spraying or planting fodder as well as seeking for veterinary treatment and artificial insemination. In households with farm workers, participants reported that these did majority of the work such as provide labor in cutting and transporting fodder from the gardens, chop and give feeds to cattle, collect and take manure to the garden as well as transporting milk to collection centres. This is true according to Njarui et al., (2009) who reports that hired labor contributes between 50-70% of the total labor required to run daily operations in the dairy enterprise in rural and peri-urban areas of Kenya. One of interviewed women during the household survey decried that she attends most of the trainings organized by the cooperative however when it comes to decision making on dairy farming matters, the husband does not listen to her, she could be one among many facing such setbacks.

5.6 Current level of adoption of Climate change mitigation practices

5.6.1 Household characteristics

The survey results indicated that majority of respondents were male 58%, however in terms of further inquiry revealed that 82% of the households were male headed compared to only 13% that were female head. This indicates that in most households it is the male who make most of the decisions regarding dairy production. This was further highlighted in the focus group discussions where participants indicated that it is male who made important decisions for example on types of fodder plants to grow as well as cattle breeds and numbers to kept. The study also revealed that majority

(67%) of respondents below age of 50 years, with 27% youths. This indicated that youth are increasingly getting involved in dairy production which can be attributed to profitability of the dairy sector in the area where closeness to Nairobi city provides ready market for milk. The study also revealed that majority (77%) of respondents attained secondary or a higher level of education and therefore could easily adopt apply good dairy production practices including climate smart dairy farming practices in the area. Dairy farming was the most important source of revenue as indicated by 79% of respondents. This was attributed to small land holding and the zero grazing system which farmers indicated that it required less land yet provided income all year round compared to crop production which required more land yet it was affected by seasonality. However close integration of crop and livestock systems ensured that both enterprises complement each other for example manure from cow shed was applied to crop land and crop residues such as maize stovers were used to feed cattle, this ensured nutrient recycling which is important for climate smart dairy production.

5.6.2 Land ownership and size

All respondents (100%) indicated that the land on which they were practicing dairy farming was secured with land titles. This is important for farmers to adopt improved dairy production and long term climate smart practices such as setting up permanent cow sheds for zero grazing as well as agroforestry practices which require a long period of time for benefits to be realized. The average land size owned by respondents in Githunguri was 3 acres compared to 0.5 acres owned in Ruiru sub county. Small land sizes were attributed to increase in population density which is severely impacting on availability of land for agriculture. In both cases, small land ownership requires that farmers adopt intensive and sustainable farming practices to meet their needs such as food, fees for children and health care among others. Hence this was observed in the close integration of crop and dairy enterprises of which respondents indicated that food crops were grown mainly for use at home while dairy provided income to meet other household needs.

5.6.3 Conservation agriculture practices, fodder production and dairy cattle feeding

Overall, the research established that over 85% of respondents in Githunguri and Ruiru sub counties already adopted conservation agriculture practices such as crop rotation, mixed cropping, mulching, manure addition and agroforestry. Through discussions with farmers, it was noted that farmers have been applying these practices for a long time through local knowledge, however, they also indicated that the cooperative organizes trainings and exchange visits with other institutions like Waruhiu agricultural college where farmers are trained in different agricultural and dairy production practices. As discussed earlier such conservation practices are important especially for smallholder farmers to ensure long term sustainability of their farming enterprises. However it was noted that these practices were mainly practiced in production of food crops such as maize, beans as well as vegetables rather than in fodder production.

In terms of fodder production, the study established that all the farmers (100%) had planted improved fodder on their farms however it was revealed that napier grass was the main planted fodder (100%) while other fodder plants such as Desmodium, Lucerne and other legumes were less adopted (less than 15% of respondents). Farmers indicated that napier was fast growing, provided higher yields and it is drought resistant therefore could be grown all year round to ensure availability of feeds for cattle. Ouma et al., (2007), asserts that napier is fast growing with high yields and provides large biomass per hectare of land compared to other forage crops, can prevent soil erosion and can remain productive for up 5 years. Famers revealed that even when they had been trained on the importance of fodder diversification, it was difficult to grow all fodder types because of the small plots of land. The same reason was given for less adoption of fodder trees where farmers indicated that grevillia was the most grown tree (85%), however its use was limited to provision of firewood and timber rather than feed for the animals. Interactions with the head of extension department indicated that the cooperative together with the sub county livestock office in Githunguri were already in plans of introducing other fast growing and high yielding crops such as maize breeds which farmers could adopt for feeding livestock. Overall, majority (60%) of farmers indicated that they had excess feeds especially during the rainy season, yet the 75% farmers indicated that they experienced feed shortage during the dry season. This highlighted the need to adopt climate smart feed conservation practices such as hay and silage making which was generally reported to be low in the area.

In terms of feeds, all respondents (100%) indicated that napier made up the bulk of feeds for cattle. Other major feeds included hay (96%) and maize stovers (90%). Farmers in Githunguri subcounty highlighted that the hay used in the area was normally sourced from other places like Nanyuki, western rift valley and Nakuru which they were able to access through agrovet shops distributed across the sub county. Farmers indicated that the price for hay was high especially in the dry season which impacted on overall feed availability for cattle. In Ruiru sub county, majority of farmers buy forages from neighbors and dry them up to make hay, however these are not enough to maintain their cattle all year round. Farmers indicated that maize stovers were readily available from their gardens however more stovers were bought from neighbors who did not keep cattle. Use of other crop residues like pineapple pulp, sweet potato vines banana pseudo-stems and weeds was reported but generally less adopted as report by less than 20% of farmers. However, Ouma et al., (2007), remarks that dry crop residues like maize stovers are relatively easy to store and use for feed in times of feed scarcity and are often available in large quantities. He notes that although they have generally low nutritive value, they can support reasonable milk yields if fed with a supplement of high nutritive value such as concentrates and legume fodder. Moreover, he further notes that use of crop residues helps to create important synergies in crop-livestock farming systems whereby crop residues are fed to cattle, reducing the need for planted or purchased fodder, while manure from the cattle is used in the field to grow crops thus recycling nutrient and helping to maintain soil fertility. This ensures that there are multiple benefits and cost savings from each enterprise.

In terms of concentrates and mineral supplement use, all farmers (100%) indicated that they use concentrates and mineral supplements. Majority indicated the use of concentrates such as dairy meal (100%), wheat bran (96%), maize germ (54%) among others, highlighting that they were of good quality and easily accessible through the cooperative stores. The main reason for feeding cattle on concentrates as reported by farmers was to increase milk production.

5.6.4 Dairy cattle management

All interviewed farmers (100%) reported that they kept improved dairy cattle breeds under zero grazing system. The main breed of cattle kept as reported by farmers was Friesian (92%) while other breeds included Ayrshire (4%), Holstein (3%) and Friesian crosses (1%), no farmer reported to keep local cattle (Zebu). The main reason for keeping dairy cattle was to generate income (73%) through sell of milk while Friesian breed was the most kept due to its high milk productivity and higher resistance to disease in compared to other exotic breeds. The average number of cattle kept in Githunguri and Ruiru sub counties was 9 and 3 cattle respectively while majority of the dairy herd constituted of lactating cows (67%) and female calves (16%) mainly kept as replacements. The research also indicated that the average milk yield produced by farmers in Githunguri sub county was 21 liters per day while in Ruiru sub county it was 16 litres per day. All interviewed farmers indicated they used AI method to improve their breeds which they reported to be reliable and readily available through AI department of the cooperative. Moreover farmers desiring to purchase high grade cows for better milk productivity were able to access Ngombe loans provided by the Cooperative SACCO.

Keeping improved high productive dairy breeds indicated that farmers were market oriented (Staal et al., 2001) since improved dairy breeds provide higher returns to investment especially in the intensive system of dairy production (Ouma et al., 2007) however this is also important for climate change mitigation since higher productivity means using less input for the same amount of output, consequently generating less waste, including greenhouse gases (MacLeod et al., 2015). Keeping cattle under zero grazing system highlighted the increasing intensification which is mainly driven by shrinking land sizes due to increase in human population in the area however this is also important for climate smartness in terms of ease of feed and manure management. Cases of diseases such as mastitis and pneumonia, were reported to be encountered in Githunguri subcounty however one of the milk graders indicated that cases of mastitis infected milk were minimal which contributed less to post harvest milk losses.

5.6.5 Water resources and availability

Respondents reported that there are a number of water sources in the area including rivers, shallow wells, Municipal (piped) water, community water system as well as rainfall, however, majority of interviewed farmers (over 90%) indicated that the main source of water for livestock was shallow well water which they say was readily available within the compound. Farmers used either electric powered submersible water pumps or manual means (both emission free) to draw water from the wells thus water was made available for cattle at all times as reported by farmers. This contributed to high milk productivity as reported by Schutz (2012) that milking cows require access to clean water at all times to ensure high milk yields. Water availability makes irrigation possible especially in the dry season, however only 29% of respondents reported to irrigate their crops with others citing lack of finances as the major barrier.

5.6.6 Manure management

Livestock manure is one of the major sources of methane and nitrous oxide if not well managed. Results from the research indicated that majority of respondents in Githunguri (86%) and Ruiru (79%) sub counties had animal sheds with different cubicles for feeding and sleeping as well as concrete floor which facilitated ease of manure collection. It was noted that majority of farmers in Githunguri (33%) and Ruiru (79%) sub counties collected and heaped manure outside the cow ban or the road roadside in open air without any form of covering. According to Gichangi et al., (2018), heaping the manure in open air where it is exposed to heat and rain contributes to nutrient losses especially through ammonia volatilization hence reducing nitrogen content. He notes that heaping and covering manure using organic material with high C:N ratio such as saw dust or maize stovers among others captures and immobilizes nitrogen which later can be applied to the gardens to contribute to soil nitrogen content hence minimizing the need to apply inorganic fertilizers. He also notes that nitrogen losses can be reduced through covering manure heaps under a shade to shelter it from rain and heat. Petersen et al., (2012) notes that covering solid manure with straw or plastic sheet reduces in general both N_2H and NH_4 and therefore total GHG emissions compared with a situation when manure in not covered. Moreover it was also noted that some farmers used water to wash out manure from the animal shed hence forming a manure pool or lagoon just outside the cow shed which according to Petersen (2012) is also a source of methane emissions and can be minimized by covering or capturing the methane gas. It was also observed that some farmers dug channels directing liquid manure to the garden. Manure composting as well as biogas production which are some of the promoted ways of combating GHG emissions in smallholder dairy production were less adopted with only 15% and 17% of farmers reporting to have adopted composting and biogas production respectively. The major barriers to adoption of proper manure management techniques were limited awareness on proper manure management methods as well as high cost to some technologies such as biogas production. An interview with the sales representative of Takamoto Biogas (a local NGO promoting biogas technology with head office in Githunguri town) revealed that the company offers a wide range of products and services in biogas technology however adoption was limited by relatively high costs as well as limited awareness on the side of farmers about the biogas production. Interactions with the head of the extension department at Githunguri DFCS revealed that no training had been previously organized specifically targeting manure management for climate change mitigation.

5.7 Current cost of milk production per litre

Results for the current cost of milk production per litre in the study area (Table 17) indicated that a farmer in Githunguri sub county on average uses 27 Kenya shillings to produce a litre of milk while in Ruiru, a farmer use on average 24 Kenya shillings. In both cases, the average cost of milk production per litre was higher than that reported for the national average which is between 16 to Kenya shilling 18 per litre (Rademaker et al., 2016). However, it should be noted that the data used for computing the cost of milk production per litre in this research was obtained from two farms, one in Githunguri and one in Ruiru sub county. Data was also collected for only the month July and extrapolated to give an indication of the annual costs of production in both sub counties and therefore may not give a clear overall picture of the cost of production both sub counties.

The difference in the cost of production can be attributed to the use of different inputs especially in form of feeds as reported by the two farms considered. In Githunguri, the farmer reported to utilize more of brewers spent grain which represented a major feed cost as indicated in table 16. The feeds were sourced from Nairobi city, a distance of close to 50 km. Transportation of these feeds also contributed further to overall costs. The farmer reported that to be only producing napier on the farm which was used to feed the cattle which indicated less diversification in terms of on farm fodder production. On the other hand, the farmer in Ruiru subcounty reported to grow diversified feed sources like maize stovers and napier and also utilized hay sourced from neighbors within the same area. Utilization of crop residues like maize stovers according to (Ouma et al, 2007) reduces the need for planted or purchased feed sources like brewers spent grain which was seen to contribute more to input costs as reported by the farmer in Githunguri sub county. Overall, diversification in feed production while incorporating legumes and fodder trees on the same piece of land is good for climate smartness as earlier discussed.

5.8 Summary of level of adoption of climate change mitigation practices

Climate change mitigation measures and practices identified in the research were clustered according to themes to give a summarized indication of the current level of adoption of the practices as shown in table 18.

Table 17: Summary of the current level of adoption of climate change mitigation practices

Themes	**Mitigation measures**	**Practices identified**	Level of adoption indicators (Red=<30%, Yellow=30-60%, Green=>60%)
1. Pasture and fodder management	1.1 Use of conservation agricultural production practices that increase soil productivity	1.1.1 Crop rotation	
		1.1.2 Mixed cropping	
		1.1.3 Mulching	
		1.1.4 Agroforestry	
		1.1.5 Terracing and contour bands	
		1.1.6 Manure application on crop and fodder plots	
	1.2 Planting of improved fodder (high yielding, fast growing, draught resistant)	1.2.1 Planting of improved fodder like napier	
		1.2.2 Incorporation of legume grasses like desmodium	
		1.2.3 Incorporation of fodder trees like caliandra, gliricidia	

	1.3 Adoption of fodder conservation techniques	1.3.1 Hay making	
		1.3.2 Silage making	
2. Feeds/concentrate rate use	2.1 Use of crop residues and agro industrial by products	2.1.1 Use of maize stovers, weeds, Potato vines, brewers waste	
	2.2 Feeding more concentrates to dairy cattle to improve productivity and reduce enteric methane	2.2.1 Concentrates used included Dairy meal, Wheat bran Maize germ, Pollard Minerals supplements	
3. Water for livestock production and irrigation	3.1 Water harvesting for dairy production	3.1.1 Use of electric driven water pumps to draw water from shallow wells	
		3.1.2 Rain water harvesting	
4. Animal welfare	4.1 Construction of zero grazing units	4.1.1 Cow shed ith concrete floor to ease manure collection 4.1.2 Cow shed with cow mat or straw in sleeping area to allow cow comfort 4.1.3 Cow shed with separate feeding and sleeping area	
5. Improved dairy breeds	5.1 Adopt and use of high yielding dairy breeds	5.1.1 Use of improved dairy breeds such as Friesian 5.1.2 Use of selective breeding system (AI)	
6. Manure management	6.1 Using solid coverage and favour cooling/shading. Capturing methane emissions for bioenergy use.	6.1.1 Biogas production 6.1.2 Manure composting	
7. Milk collection and transportion	7.1 Effective milk collection system to minimize emissions	7.1.1 Milk collection centres located at walking distance from farmers 7.1.2 Use of milk transport means that do not emit GHG such as milk troleys/wheel barrows, bicycles	

From table 18, it can be noted that majority of smallholder farmers under Githunguri DFCS Ltd had adopted and were already implementing practices that contribute to climate change mitigation. This indicated by color green in the table which show over 60% of farmers were already implementing the practice. However it was also noted that there are climate change mitigation practice that were not well adopted by the time of the research, these are indicated by colors yellow showing that between 30-60% of farmers had adopted the practice while and color red indicated that less than 30% of the farmers had adopted the practice. Farmers cited different reasons/barriers why some of the practices were less adopted and these are summarized in table 19 highlighting proposed solutions.

Table 18: Reasons for low adoption of some of the climate change mitigation practices and proposed solutions for scaling up

Challenge area	Reason/barrier	Proposed solutions	Responsibility
1. Low adoption of high yielding fodder, legumes and fodder trees on farmland	• Small plots of land do not favor diversification in forages and inclusion of fodder trees	• Increase sensitization on merits of agroforestry as well as legumes and fodder trees association in farmlands to promote nutrient recycling as well as climate change mitigation.	Githunguri DFCS extension department, CSA service providers
2. Low adoption of fodder conservation techniques	• Little or no fodder to be conserved due to small plots of land for fodder production	• Promote faster growing, drought resistant and high yielding fodder plants • Promote irrigation to ensure all year round fodder production • Promote rain water harvesting and water management systems that contribute to recharging of aquifers	Githunguri DFCS extension department, Agricultural Research institutions e.g. Waruhiu Agric. College, KARLO, Irrigation service providers, CSA service providers
3. Poor methods of manure management	• Limited awareness on proper manure collection and disposal techniques including biogas production	• Coordinate trainings on proper manure collection and disposal methods • Increase awareness on merits of manure composting and biogas production through production and dissemination of education and communication materials	Githunguri DFCS extension department, Githunguri DFCS extension department, CSA service provider
	• High cost of biogas technology	• Organize tailor made payment system with service providers to install biogas for interested farmers • Liaise with CSA promoters for possible subsidies (co-funding) on installation of biogas and generally for sensitization on Climate smart dairy production	Farmers, Githunguri DFCS production department, Githunguri dairy farmers' SACCO, Biogas service provider like Takamoto Biogas, CSA service providers

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter provides a summary of results from the research in a way to address the objective and answer the questions set out in the introduction part of this thesis repot. The main aim of the research was to identify best practices in climate change mitigation in smallholder dairy value chains in order to develop interventions for scaling up of sustainable climate smart best practices that support low-emission dairy production in the Githunguri dairy value chain. The conclusion and recommendations have been drawn and are presented in the different sections below.

6.2 Conclusion

6.2.1 Governance of Githunguri dairy value chain

Githunguri DFCS ltd is a strong and vibrant farmer owned dairy cooperative society offering a wide range of products and services to its members and general population in Kenya. Its strengths is attributed to a well-organized management team organized in different departments to ensure effective service delivery. A strong membership of 24,936 men and women supplying an average of 250,000 litres of milk daily ensures that the cooperative continuously processes and markets dairy products to the benefit of its members. Two governance types were identified including the market and modular type. The market type was observed mainly in Ruiru sub county where some dairy farmers sell milk through the informal chain to immediate neighbors hence the cooperative needs to address this issue to ensure that all its members deliver milk to the cooperative. The modular type of governance was observed in Githunguri subcounty where majority of farmers deliver all their milk to the cooperative and the milk accepted or rejected based to quality test. Milk payments under the cooperative are volume based.

6.2.2 Current dairy production practices that contribute to climate smartness in the study area.

It was observed that majority of respondents in the study area were not aware about climate change and climate smart agriculture but results indicated that smallholder dairy farmers were already implementing practices that contribute to climate change mitigation such as use of high productive dairy breeds like Friesian cattle among others. Practices such as use of conservation agriculture practices like mulching, intercropping, use of cover crops, agroforestry were identified to contribute to different climate smartness categories. Use of emission free mean like milk trolleys, bicycles to deliver milk and use of emission free technologies like electric driven chuff cutters, electric water pumps were also identified to contribute to climate smartness.

6.2.3 Role of gender in ensuring climate smart dairy farming

It was observed that women were more involved in daily farm activities while men were more involved in decision making such as resource allocation on the farm. In households with no farm workers, it is mainly the work of women to carry out practices such preparation of land for fodder production, ensuring cattle had sufficient feeds and water cleaning of the cow barn as well as manure collection among others. Men were more responsible in decision making on matters on resource allocation like which fodder to plant, what type of dairy cattle to keep among others and also in liaising with veterinarians in cases of disease outbreaks on the farm among others.

6.2.4 Scalable climate smart practices

In general it was observed that farmers were not aware about climate smart dairy farming however they had already adopted and were implementing practices that contributed to climate smartness as earlier discussed. This was made possible through good coordination as well as training and extension services offered by the cooperative. A number of climate smart practices that can be scaled up were identified as earlier mentioned and it was also noted that both men and women were involved in implementing climate smart practices with women being more involved in daily activities while men were more involved in decision making and resource allocation.

6.2.5 Current level of adoption of practices that contribute to climate smartness

Results of the survey indicated that some of the climate smart practices were already adopted by majority of farmers while others were less adopted. In terms of fodder production and management over 60% of farmers reported that they were already carrying out conservation agriculture practices like crop rotation, mixed cropping and manure application in the gardens. All farmers were growing napier which is fast growing and high yielding fodder making up the bulk of cattle feeds in the area. However there was limited diversification the terms of fodder plants grown of farms which the research identified as a loophole in terms of climate smartness. In terms of feed and water for cattle, over 60% of farmers reported to use concentrate to increase milk yields, water was made available for cattle at all times through effective water harvesting means either manually or using electric water pumps to draw water from shallow wells which were located within the household compound. In terms of animal welfare and keeping of improved dairy cattle breeds it was noted that over 60% of farmers had zero grazing units with separate feeding and sleeping area, provided cow mat to ensure comfort, concrete walking area ensured ease of manure collection. Major cattle breed kept was Friesian which is a high milk producing breed. In terms of milk transportation to collection centres, over 60% of farmers had adopted use of emission-free mean like trolleys and bicycle. Some of the practices that were less adopted as reported by less than 60% of farmers included manure management practice that reduce GHG emissions such composting and biogas production, feed conservation practices like hay and silage making. Farmers cited different reason as to why some of the practices were less adopted such as limited awareness of the CSA practices as well as high cost of some mitigation technologies.

6.2.6 Current cost of milk production

The calculated cost of milk production per litre in the study area was 27 and 24 Kenya shilling for Githunguri and Ruiru sub counties respectively however the cost was found to be higher than that reported for the national average which is between 16-18 Kenya shillings (Rademaker et al., 2016). The figures used in the cost calculation were collected from only 2 farms and may not give a clear overall cost of milk production in the study area.

6.2.7 Support required for scaling up climate change mitigation practices

A number of challenges that hinder adoption and scaling up of some of the climate change mitigation practices were identified to include limited awareness and high cost of some climate change mitigation practices among others. These informed the basis of identifying interventions and generating business models that support scaling of climate change mitigation as presented in the recommendations section below.

6.3 Recommendations

The recommendations are presented in two fold and include interventions for scaling up of climate change mitigation as well as proposals on business models that contribute to upscaling of climate change mitigation/climate smart agriculture. These are discussed further in sections below.

6.3.1 Interventions for scaling up of climate change mitigation in the Githunguri dairy value chain

Challenges notwithstanding, interactions with farmers in both sub counties of Githunguri and Ruiru indicated that they were interested in knowing more about climate change and climate smart dairy farming. Farmers also indicated that they were willing to invest in low cost climate smart technologies as seen in the use of some of the technologies already adopted which included; electric chuff cutters, electric water pumps, and milk trolleys among others owned by majority of the farmers.

The head of the extension department indicated that the cooperative was ready to include climate change and climate smart agriculture in its training schedules as long as farmers demanded for such trainings and an appropriate service provider identified.

The water officer at Githunguri DFCS noted that climate smart agriculture was a new topic to him however he pointed out that awareness regarding issues such as climate change and climate smart agriculture was lacking and knowledge of such practices would contribute to recharging of the aquifers. He noted that dairy farming was already facing competition for water resources from the construction sector as well as the increasing population citing climate smart agriculture would offer some of the solutions to the increasing threat on water availability in the area.

The sales representative from Takamoto biogas company highlighted that the company offers a number of products and services in clean energy production including construction of different types of bio-digesters such as top flame (reinforced plastic canvas) biogas system, fixed dome biogas system, bio-septic tanks among others as well as supply of different biogas appliances. He pointed out that the company was pioneering a technology that uses biogas to run chuff cutters which would relieve farmers from monthly payments for electricity bills along other benefits. However, he mentioned that the main challenges encountered in adoption of renewable energy (biogas) technology were limited awareness among farmers as well as the high cost of setting up of some the climate smart technologies like biogas production. He mentioned that the company was open to creating partnerships that would foster adoption of renewable energy and in general climate smart technologies.

Therefore interventions for scaling up of climate change mitigation in the study area should first focus on creating awareness about the issue of climate change and therefore the need to adopt climate smart agriculture practices. This can be done through production and dissemination of Information, Education and Communication (IEC) materials to farmers in the study area. Use of mass media communication such as radio, television and new paper advertisements will ensure that a wide range of the farming population is reached. Also use of social media targeting farmers in the area will contribute to overall sensitization.

Physically reaching out and training farmers in the study area will ensure that farmers have access the knowledge regarding climate change mitigation and as such can be expected to implement the practices. The best approach for Climate change mitigation/CSA Promoters to effectively reach out and train farmers is through the Cooperative which is mandated to offer monthly trainings and extension services to all its farmers who are organized according to different milk collection routes. It is also important that the extension officers under the cooperative are adequately trained in climate change mitigation/Climate smart dairy production practices as these will cascade trainings further to farmers across the board. Extension officers are in regular contact with individual farmers and will be significant in providing backstopping information/messages to the farmers.

Whereas farmers were willing to adopt climate change mitigation practices and technologies, some of the effective methods and technologies such as biogas production and irrigation systems were costly as reported by farmers, therefore building alliances of climate change mitigation/CSA promoters who are willing to fund either in part or fully to ensure adoption of the different practices and technologies as well as bringing on board local service providers would contribute to increased adoption of the different practices and technologies in the study area.

6.3.2 Business models for scaling up climate change mitigation in Githunguri dairy value chain

Basing on the barriers as well as the proposed interventions to scale up climate change mitigation, two business models have been developed to give an indication of how such barriers can be addressed in the study area. The business models are organized according to who pays for the climate change mitigation products and/or service. Key actors in the business models are;

I. Farmers: These are consumers of CSA products and services and are thus termed as clients in the business models.
II. Githunguri DFCS ltd: This is farmer organization through which CSA interventions or packages intended for farmers can be channeled.
III. Githunguri Dairy Farmers and community SACCO: This is a semi-autonomous financial agency under Githunguri DFCS ltd where all farmers' milk payments are channeled through.
IV. Service providers: It I noted that not all climate change mitigation/CSA service providers are able to offer/install CSA technologies like biogas. Therefore two service provider are identified for the business models i.e. those that provide CSA awareness and those that do actual installation of CSA technologies like biogas.
V. Funders: Funding for the different CSA products and services can be done by either the farmers or the cooperative or an external funder such as government or a development partner.

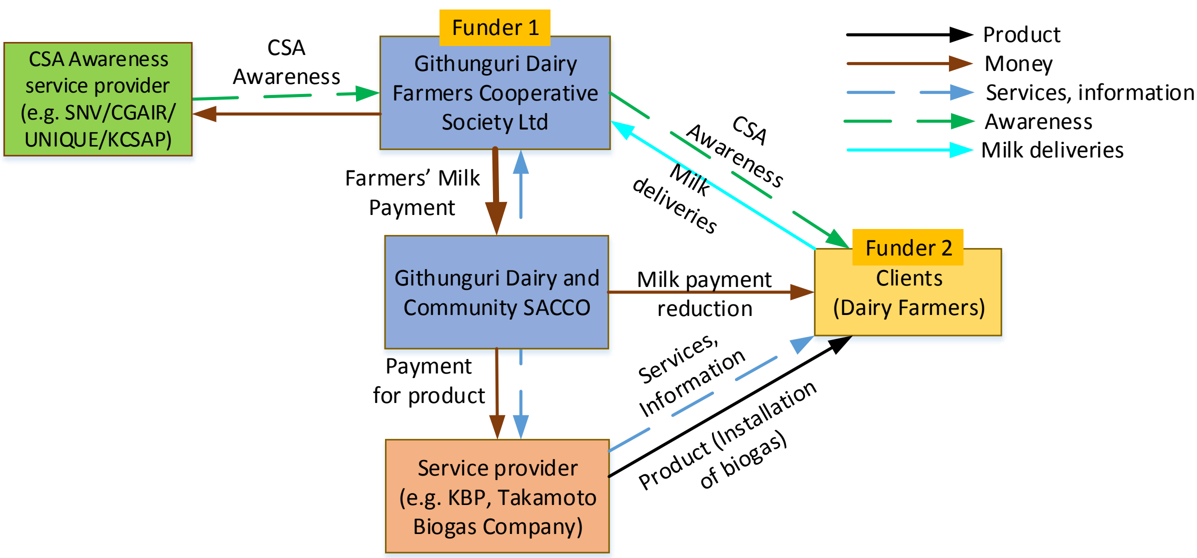
Types of models.

Business Model 1: CSA products and services paid by cooperative and individual farmers

This kind of model depicts a situation where the cooperative and individual farmers pay for different Climate smart package as shown in figure 31.

Scenario 1: The cooperative (Funder 1) pays for CSA services on behalf of farmers. The Cooperative may hire Climate Smart Agriculture service providers to offer training packages in climate change mitigation interventions to its farmers. Motivation for this is that the cooperative aims at sustainably increasing milk production of its members hence increased milk supply to the cooperative for product processing. This kind of scenario is already employed by the cooperative whereby it hires different service providers to offer trainings to farmers on different topics as requested by farmers. Some of the identified CSA service providers who are also participating in the Kenya dairy NAMA include Dutch development Organization (SNV), Consultative Group for International Agriculture Research (CGIAR), UNIQUE Agroforestry and Land Use, Kenya-Climate Smart Agriculture Project (KCSAP), Hivos, and Kenya Biogas Group (KBG) among others (CGIAR, 2018).

Figure 31: CSA services and products paid for by cooperative and individual farmers



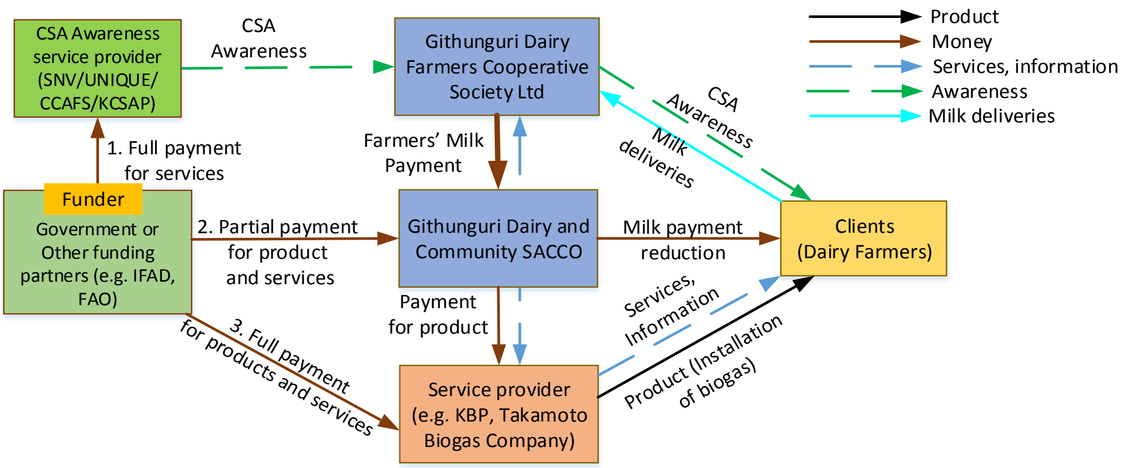
Scenario 2: Farmers (Funder 2) pay for products and services through milk deliveries to the cooperative. It is believed that once farmers have been sensitized in the different climate smart agriculture packages, some may want to adopt some of the technologies such as biogas technology. However one of the barriers reported by farmers to adoption of climate smart technologies was that farmers had insufficient funds. Through coordinating with the cooperative and the SACCO for a loan arrangement, farmers can be able to procure CSA technologies from service providers such as biogas installation services offered by the Kenya Biogas Project (KBP) or through a local service provider such as Takamoto Biogas Company. The cooperative advances the full amount required to install the biogas plant to the service provider at the farmer's request and the farmer pays back for the loan in instalments to the SACCO through milk deliveries to the cooperative. This kind of arrangement has been on going through the milk advance loan offered by the SACCO as reported by the head of the extension department at Githunguri.

Business Model 2: Fully paid or Subsidized (partial) paid products and services by Government or Development partner.

The second business model (figure 32) depicts a situation where there is an external source of funding provided by promoters of climate change mitigation actions/climate smart agriculture such as the Government of Kenya or a Development partner such as UN through IFAD of FAO (both partners in the Kenya dairy NAMA) (CGIAR, 2018). Three scenarios are identified for this kind of model.

Scenario 1: Government or the Development partner (IFAD, FAO) as CSA promoting agencies may facilitate sensitization on climate smart agriculture through CSA service providers such as SNV, UNIQUE Agroforestry and Land Use, as well as KCSAP among others. By collaborating with the cooperative, the CSA service providers will be able to reach out and sensitize/train/equip dairy farmers with information on climate smart dairy production.

Figure 32: Fully paid or Subsidized (partial) paid products and services by Government or Development partner



Scenario 2: Partial payment for CSA product and services by government/Development partner. In this scenario the government or Development partner may want to provide co-funding for farmers to adopt some of the CSA practices and technologies. Government or development partner will channel the co-funding through the Cooperative SACCO. Also interested dairy farmers will provide co-funding

through milk deliveries to the cooperative. An appropriate service provide will be contracted by the cooperative in collaboration with the funding agency to offer CSA products and services to farmers.

Scenario 3: Government or Development partner fully pays for CSA products and services to the service providers on behalf of farmers. In this case, government or Development partner identifies and pays a suitable CSA service provider such as KBP or Takamoto biogas company to install CSA technologies on behalf of farmers. The CSA service provider collaborates with the cooperative to effectively reach out to farmers and provide CSA products and services.

6.3.3 Sustainability of climate change mitigation interventions

Climate smart agriculture has been identified as one of the avenues to sustainably increase agricultural production, provide incomes for smallholder farmers as well as contributing to climate change mitigation. Therefore effective adoption and implementation of the proposed interventions will ensure sustainability of the systems as discussed below in terms of people, planet and profit.

People

Adoption of climate change mitigation practices like biogas production will improve overall standards of living and contribute to general wellbeing of rural communities through providing an alternative and sustainable source of clean energy for cooking and lighting. Adoption of climate smart agriculture practices that contribute to efficient land use will ensure overall productivity hence food availability for communities.

Planet

Adoption of effective means of manure management like composting and use of bio-digesters reduces overall greenhouse gas emissions and application of the manure and bio-slurry in crop and fodder fields contributes to nutrient recycling which is important for regeneration of ecosystems.

Profit

Scaling up of sustainable methods of production like integration of crop-livestock systems and effective management of both systems will result in overall increased farm output in form of crop and dairy products which ensures profits to the farmers.

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ANNEX

Annex 1: Questionnaire

Section I: Household Information

1. Name of Household Head……………………………………………..
2. Name of Respondent…………………………… Sex of Respondent [1] Male [2] Female
3. Village……

Section 2: -Respondent's Information

1. How many people are in your household? ………
2 . Age group of the respondent in years……………………..
   00=<20 01=21-40 02=41-60 03=Above 60
3. Respondent's highest level of education
   00=No formal education 01=Primary 02=Secondary
   03=Tertiary(Certificate, diploma, degree)
4. What is your main source of income?
   00=Farming 01 =Formal employment 02=Business 03=other (specify)……
4. What is your main farming activity? …….

Section 3 Landholding

1. Total land holding (acres)
   00=0-2acres, 01= 3-5Acres, 02=6-10acres 03= Others (specify)…….
2. Total land size allocated to dairy farming in acres
   00=<0.5 acres, 01=0.6-2acres, 02=3-5acres 03=6-10acres 04=Others (specify)…..
3. Land tenure system
   00=Secured title deed, 01=Secured but family land, 02 =Squatter
4. Do you currently rent more land for dairy farming? 00=Yes 01=No
5. If the answer in question 4 is yes, what is the size of extra land you rent?
   00=<0.5 acres, 01=0.5-2acres, 02=2-5acres 03=5-10acres 04=others specify
6. Have you hired labour on your farm in the last 12 months?01= No……… 02=Yes…..
7. If yes, how many and for how long: No……….. Months…………..

Section 4 Fodder, conservation agriculture practices and feeds for dairy cattle

1. Have you planted fodder on your farm? 01=No……… 02=Yes……..
2. If yes, What types of improved fodders have you planted? tick appropriately

   01=Napier grass, 02= Desmodium, 03= Brachiaria, 04= others (Specify)....

   05=Herbaceous legumes: 06= alfalfa, 07= others (Specify)....
3. What is the main reason for choosing the planted fodder/pastures on your farm

01= Easy to plant and manage 02= planting material available 03=High yielding

04= drought resistant 05= Other….

4. What determines area of the farm on which you plant fodder
   01= Land size 02=Number of livestock 03=Other….
5. Have you planted fodder trees? 01=Yes 02=No
6. If yes, what type of trees have you planted?
   01=Grevillia 02=Calliandra 03=Lucerne 04=Other…….

7. What major barrier do you face in establishment of improved fodder?
   1=Small land size; 2=Lack of seeds/planting materials; 3=Lack of labour; 5= Lack information on fodder types to plant; 6= Lack of money for establishment; 7=Other (specify)
8. In the last 10 years how has been the trend in fodders yield per acre in your farm

   01=slightly increased 02=No change

   03 significantly decreased

9. What do you attribute the changes in question 4?

   00= Poor soil fertility 01=unreliable rainfall 02=Addition of manure

   03=Others (specify)…..

10. What feeds do you normally use to feed your dairy cows?

Type of feed	Tick what applies	Concentrates
00=Napier		00=Dairy meal
01=Fodder maize		01=Wheat bran
02=Maize stovers		02=Maize germ
03=Banana pseudo-stem		03=Pollard
04=Hay/silage		04=Mineral supplements
05=Other crop residues(specify)…		05=Other (specify)….

10. Have you had surplus fodder in the last 10 years? 00=Yes 01=No

11. If yes what do you do with surplus?

01= Sell to neighbours 02=Conserve into hay 03=Just leave it on the farm 04=Conserve to silage

12. Have you experienced fodder shortage in the last 10 years? 01=Yes….. 02=No…..

10. If the answer to the above is yes which months of the year? Tick

J	F	M	A	M	J	J	A	S	O	N	D

13. How do you cope with fodder/pasture shortage?

00=Buy from cooperative 01= Use conserved fodder and pasture 02= Buy from agrovet shops

03= buy from neighbours 04=Other (specify)…..

14. What conservation agriculture practices do you apply when growing fodder?

00=Crop rotation 01= Mixed cropping 02= Double digging 03=Agroforestry 04=Terracing 05=Mulching 06=Others (Specify)……..

15. What is the main reason you apply such practices mentioned in question 14?

    00=For water retention 01=Improve soil fertility 02=Improve yield 03= reduce soil erosion 04=Others Specify

16. Do you irrigate your fodder/pasture? 00=Yes 01=No
17. What type of irrigation do you use. 01=Sprinkler 02=Drip 03=Other
18. If no, what are the barriers to adoption of irrigation?
    01=Lack of money 02=Lack of information about irrigation 03=Lack of technology 04small plot of land 05=Other…

SECTION 5: Dairy Cattle Management

1. Where do you feed your cattle? 1=Stall 2=Graze in paddocks 3=Graze on communal land
2. If fed in a stall, what is the floor type 01) Concrete 02) Earth
3. How many dairy cattle do you own now? Total ………… Milking cows.........Dry cows……Heifers………… Calves- Female………Male…..
4. What is your main passion for keeping dairy cattle?

   00=Food 01=Income 02=Manure 03= Breeding 04=Feed production 05=Other…….
5. What type of dairy cattle do you keep?

   00=Friesian 01=Ayrshire 02=Holstein 03=Cross 04=Zebu

8. What is the average milk yield per cow per day on your farm? Quantity………..l
9. What is the average calving interval? Days………….
10. What is the distance (km) to the nearest milk collection centre?

    00=<500m 01=600-1.5km 02=1.5-3km 03=>4km 04) Other (specify)……..
11. What means do you mainly use for transporting milk to the collection centre?

    00=On foot 01=Bicycle 02=Motorcycle 03=Milk van/lorry 04=Other (specify)…….

SECTION 6: Water resources and availability

1. What is your main source of water for livestock use

   00= River/Stream 01=Borehole 02= Water pond/Dam

   03= Roof catchment 04=Piped water 05= Shallow well 06=Others (specify)……..
2. How far from your farm is the water source for your livestock

   00=<200m 01=200-1km 02=2-3km 03=>3 km 04=Other (specify)…….

ow do you make sure 3. How do you make sure that cattle have water all the time?

01=Use electric pump 02= Draw water manually 03=Other (Specify)….

SECTION 7: Manure management

1. Have you collected livestock manure from your farm in the last 12 months?0=No 1=Yes
2. If yes, In which way do you use the manure? 00=Make compost 01=Produce biogas, 02=Dry apply on the farm/garden 03=Spread raw manure on the farm 04=Sell it 05= Other…

3. If you do not practice compositing, why not? [select one]

1= Lack of labour to collect manure; 2=Small manure quantities; 3=time consuming; 4= don't know how to do composting; 5=Other

4. Do you have a biogas digester? 0=No; 1= Yes (functioning)
5. If no, what in the main barrier to adopting biogas production?
   1=Lack of money 2=Lack of information about biogas 3=Few number of cattle 4=Other…

Annex 2: Average land owned by respondents

Group Statistics

	Name of sub county	N	Mean	Std. Deviation	Std. Error Mean
Land owned by the respondents (Acres)	Githunguri	24	2.85	2.107	.430
	Ruiru	24	.47	.315	.064

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
Land owned by the respondents (Acres)	Equal variances assumed	14.357	.000	5.485	46	.000	2.385	.435	1.510	3.261
	Equal variances not assumed			5.485	24.031	.000	2.385	.435	1.488	3.283

Annex 3: Average land allocated for dairy farming

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
Land allocated for dairy farming	Equal variances assumed	21.343	.000	4.320	46	.000	.833	.193	.445	1.222
	Equal variances not assumed			4.320	24.685	.000	.833	.193	.436	1.231

Annex 4: Average number of cattle kept and number of cows in milk

Statistics		Total number of cattle kept		Number of cows in milk	
		Githunguri	Ruiru	Githunguri	Ruiru
N	Valid	24	24	24	24
	Missing	0	0	0	0
Mean		9.17	3.29	4.96	1.71
Std. Error of Mean		.870	.298	.618	.175
Median		10.00	3.00	4.00	1.50
Mode		3[a]	2[a]	4[a]	1
Std. Deviation		4.260	1.459	3.029	.859

a. Multiple modes exist. The smallest value is shown

Annex 5: Average milk yield

Group Statistics

	Name of sub county	N	Mean	Std. Deviation	Std. Error Mean
Average milk yield per cow per day	Githunguri	24	20.58	5.860	1.196
	Ruiru	24	15.58	4.242	.866

		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
Average milk yield per cow per day	Equal variances assumed	5.479	.024	3.386	46	.001	5.000	1.477	2.028	7.972
	Equal variances not assumed			3.386	41.910	.002	5.000	1.477	2.020	7.980

Annex 6: Implementation matrix to ensure proper manure management

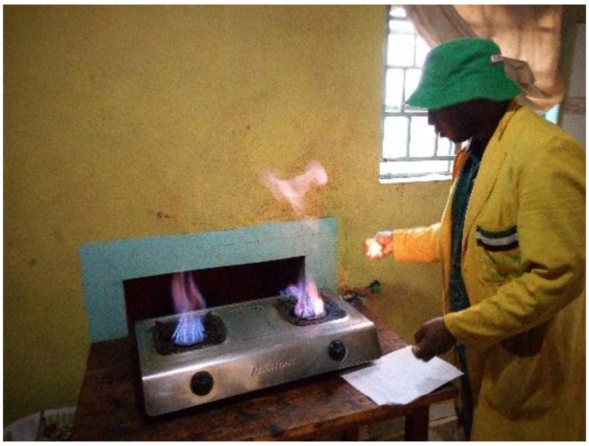
Current Situation	Target	Strategies	Responsibility	Input	Output	Outcome	Impact
Less than 20% of smallholder dairy farmers under Githunguri DFCS Ltd are aware about proper manure management practices and hence CSA practices such as manure composting and biogas production are inadequately adopted and implemented	Over 80% of dairy farmers equipped with adequate knowledge and able to implement sustainable practices in manure management	1. Establish linkages with Githunguri DFCS Ltd and sesitize farmers about proper manure management methods					
		Activity 1.1: Conduct a formal meeting with Githunguri DFCS Ltd	NWO-CCAFS (CSDEK) project or Other CSA promoters like FAO, ILRI, UNIQUE, KCSAP	Human Resources, time, funds, meeting venue, refreshments, Cooperative management members, farmer representatives	1 Stakeholder meeting held with Githunguri DFCS Ltd to create an understanding (MoU) for sensitizing farmers on proper and sustainable manure management practices	Knowledge and awareness about the contribution of manure management to overall climate change mitigation and sustainable dairy production	Githunguri DFCS Ltd management aware and includes trainings on proper manure management in its training and extension programs
		Activity 1.2: Conduct farmer training on proper manure management techniques like composting and biogas production	NWO-CCAFS (CSDEK) project or Other CSA promoters like FAO, ILRI, UNIQUE, KCSAP, KBP Githunguri DFCS LTD	Trainers, training materials, training venue, refreshments, time, dairy farmers, funds	10 cluster trainings (1 training per route) held for smallholder dairy farmers under Githunguri DFCS Ltd on proper manure management methods	Farmers aware and implement proper manure management practices in manure collection, storage and application	Overall reduction in emissions from manure management Production of renewable energy contributing to cost saving and overall health standards

Annex 7: Field Pictures


Manure application in the field


Agroforestry


Biogas plant


Biogas stove


Chopped feeds


Fresh stored feeds