Scalability of climate-smart practice in forage supply chains. Case study of Githunguri and Olenguruone dairy societies in Kiambu and Nakuru Counties-Kenya

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Scalability of climate-smart practice in forage supply chains. Case study of Githunguri and Olenguruone dairy societies in Kiambu and Nakuru Counties-Kenya

Research Thesis Submitted to Van Hall Larenstein University of Applied Sciences In Partial Fulfilment of the Requirements for Degree of Master in Agricultural Production Chain Management, Specialization Livestock Chains

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

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Abbreviations

CH4- Methane
CO2- Carbon dioxide
CSDEK Climate-Smart Dairy in Ethiopia and Kenya
GAP – Good Agricultural Practices
GHG- Greenhouse gases
ICRAF- International Council for Research in Agroforestry
ILRI- International Livestock Research Institutes
IPPC- Intergovernmental Panel on Climate Change
KALRO- Kenya Agricultural and Livestock Research Organisations.
KEBS- Kenya Bureau of Standards
KEPHIS- Kenya Plant Health Inspectorate Service
LCA- Life Cycle Analysis
MoALF- Ministry of Agricultura, Livestock and Fisheries
N_2- Nitrogen
NGO- Non-Governmental Organisation
SACCO- Saving and Credit Cooperative Organisations
SNV- Netherlands Development Organisations

ABSTRACT

Livestock supply chains are a significant source of global greenhouse gas (GHG) emissions, and emit an estimated 7.1 Gigatonnes of carbon dioxide-equivalents per year, representing approximately 14% of all human-induced emissions as per Gerber *et al*. (2013). GHG emissions of the livestock sector are mainly comprised of methane (44%), nitrous oxide (29%) and carbon dioxide (27%).

The study was to find out the climate-smart practice along the forage value chain in Githunguri and Olenguruone dairy farmers cooperatives in order to develop a sustainable business model.

From the findings, actors the cost of production is increasing due to environmental, economic and social factors. Environmental factors include land used management, GHG emission, energy consumption. Economic factors include demand and supply financial constraints, interest rates, taxes and inflation. Finally, on social factors include stakeholders' relationship and chain governance.

To address these challenges to upscale for the sustainability of the forage value chain, the research suggested that, chain governance should be upgraded to be more inclusive, this will accommodate the social issue in terms relationship through coordination and collaboration of chain actors and stakeholders. Also the introduction of climate-smart technologies and the development of an inclusive business model.

CHAPTER ONE: INTRODUCTION

Global climate change is primarily a result of greenhouse gas (GHG) emissions resulting in the warming of the atmosphere (IPCC, 2013). Agriculture, forestry and other land use contribute 24% of total GHG emission as per the report of IPCC 2014. The livestock sector contributes 14.5% of global GHG emissions, which has affected livestock production Gerber et al, (2013). This is evidenced by competition for natural resources, low quantity and quality of feeds, livestock diseases, heat stress and biodiversity loss while the demand for livestock products is expected to increase by 100% by mid of the 21st century (Garnett, 2009).

1.1 Country overview

Dairying is one of the most significant livestock investments owing to its characteristic value and potential. The dairy industry accounts for 4% of Kenya's GDP. NAFIS (2019) report estimated Kenya's milk production to be about 5 billion litres against the consumption of 7 billion litres per annum. This translates to a deficit of 31.8 to 43.5% for medium growth rate, and 16.8 to 32.8% for high growth rate. Notably, smallholder farmers contribute over 80% of total milk production, 56% of milk sold in the unregulated (informal) market.

There has been an increase in the number of smallholders in rural and peri-urban areas across Kenya due to land pressure; dairy farming is under zero-grazing, (intensive system) as a component of an integrated farming system. As a result, the greatest constraint to livestock productivity is the shortage of feeds and forages especially in the dry season (Ayantunde et al 2005). Farmers are not able to provide sufficient quantities and quality feeds to their livestock on a consistent basis (Hall et al 2007). On the other hand, Wambugu (2011) indicated that feed and fodder account for 60% -70% of total cost in livestock production. Moreover, Climate change is the root cause, with substantial impacts on ecosystems and the natural resources, which the livestock sector depends. In this regard, Kenya as a country, suffers a large deficit of livestock feeds, primarily forage for dairy cattle. With this increased demand for forage, forage value chain necessitate the need to re-position the chains with a view to addressing fodder availability, quality and affordability issues. Smallholder dairy farmers with their small parcels of land are not able to produce to their potential, due to their small-scale enterprises; therefore, as a result, commercial fodder sector is emerging in Kenya USAID-KCDMS, (2018).

1.2 Dairy farming in Githunguri sub-county

Githunguri sub-county is one of twelve constituencies in Kiambu- Kenya. Based on research done by Shumba (2018), stipulates that the majority of farmers keep their livestock under the intensive system due to land size challenge. Feed such as concentrates and forage are outsourced from other counties like Nakuru, Narok and West Rift Valley among others. Shumba further explained that, though dairy farmers outsourced their forage, there is no solid relationship among the chain actors (with the forage producer, traders and end consumers). This has led to unreliable supply and price fluctuation of forage. Githunguri Dairy Cooperative being farmers' cooperative, plays a critical role in supplying dairy feeds (fodder and dairy concentrate) to its members

1.3 Project description

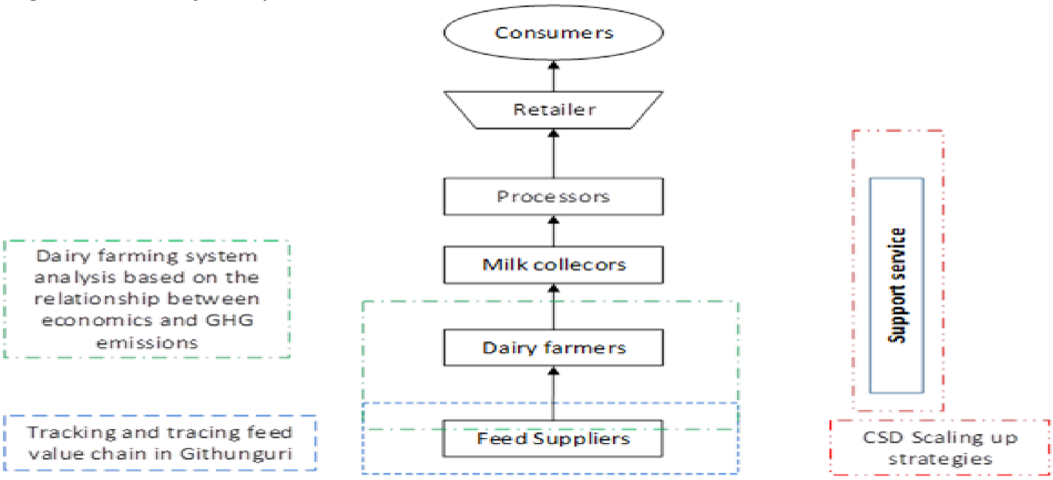
Van Hall Larenstein University of Applied Sciences through the Dairy value chain sustainable agribusiness in metropolitan areas professorships got research call from CCAFS (Research Program on Climate Change Agriculture and Food Security) in scaling up good climate-smart practices in the dairy sector in order to increase production and reduce GHG emission. The research aims to describe business models of chain actors and supporters to identify opportunities for scaling up good climate-smart dairy practices in Ethiopia and Kenya. CCAFS is linked to "Nationally Appropriate Mitigation Actions" (NAMA- which was chosen by the Kenyan government during Paris conference on climate change) to reduce GHG emissions from dairy production. Despite initiatives in the dairy sector, scaling up of good practices is lagging. A team of researchers, Climate-Smart Dairy in Kenya (CSDEK) 2018 carried out research in Githunguri- Kiambu County with the aim of scale-up climate-smart practice in smallholder dairy farmers. However, based on their findings, Kiiza and Shumba (2018), scaling up climate-smart dairy practices is a challenge due to small land sizes and the majority of farmers are sourcing their feeds from other regions. Due to the high cost of production in the dairy sector and low supply of forage, farmers tend to buy any available feeds and cheap. These might be of poor quality thus leading to high GHG emission and low production in dairy farming. In addition, Kiiza (2018) also reported that the Rhode grass hay is the major forage used in the area beside the Napier grass, which are available in the area. Based on their findings, farmers acquire this kind of forages from local stockist (Agro-vets), Dairy Cooperative stores and some buy from the other farmers. According to Shumba (2018) Githunguri DFCS plays a crucial role in the forage value chain. The cooperative acquires different types of feeds amongst forage (only Rhode grass hay) and sale to their dairy farmers through a check-off system. However, not all farmers buy from their cooperative outlets but from other private stockist or from roadside traders. CSDEK 2019 carried out research on economics and GHG emission in dairy farming systems and forage value chain analysis in Kenya and scaling up Climate Smart Dairy strategies in Ethiopia as shown in Figure 1.

The aim of this research was to carry out an in-depth analysis into forage value chain, identifying forage chain actors, supporters and estimate cost of production, GHG emission and energy consumption at production level and along the chain, with the objective of developing business model for scaling up climate-smart dairy farming practices in Githunguri and Olenguruone Dairy Farmers Cooperatives.

Problem owner - Van Hall Larenstein University of applied science

Commissioner VHL Applied professorships in the dairy value chain and Sustainable agribusiness in metropolitan areas.

Figure 1: Area of study in Value Chain



Source: Author 2019)

1.4 Research problem

Integration of climate-smart practices to smallholder dairy farmers in Githunguri remains to be a challenge as identified by Shumba (2018), dairy farmers are not able to produce their own forage due to small sizes of land for that reasons they purchase from different regions. The source of forage, forage value chain and greenhouse gases are not known.

1.5 Research objective

To carry out a case study on the forage supply chain in Githunguri and Olenguruone Dairy Farmers Cooperatives in order to advise the commissioner on scaling up climate-smart dairy practices through business models and type of forage chain governance.

1.6 Research questions

1. What is the existing forage supply chain in the Githunguri and Olenguruone dairies?

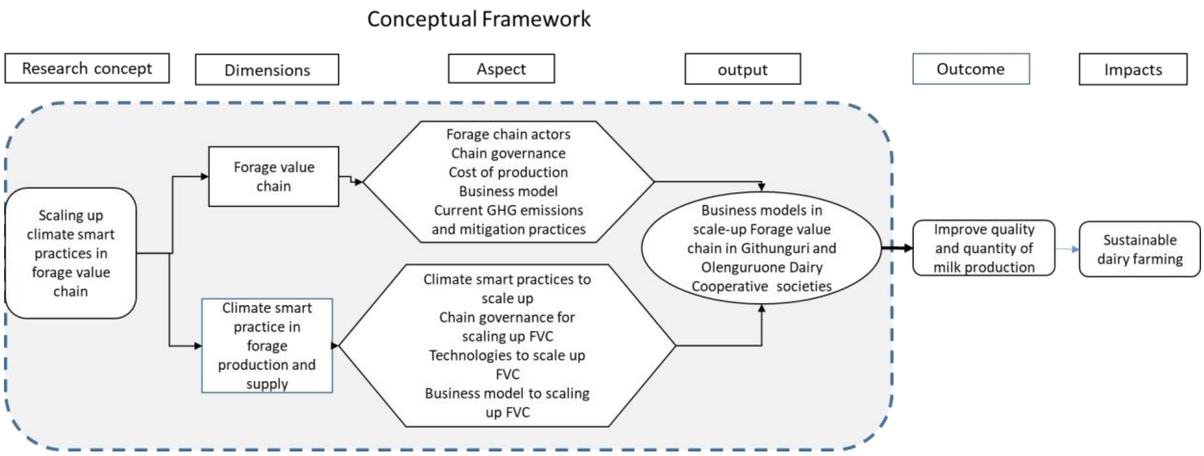
    1.1 What are the existing relationships among forage chain actors?
    1.2 What is the cost of forage production?
    1.3 What is the level of demand and supply for forage in Githunguri and Olenguruone?
    1.4 What is the capacity of forage producers and key suppliers to meet demand?
    1.5 What is the status of GHG emission and energy consumption along the forage supply chain?

2. What are the scalable climate-smart practices in fodder production and its suppliers?

    2.1 What climate-smart technologies that can be implemented in scaling up forage production and supply in Githunguri and Olenguruone?
    2.2 What are the possible business models and chain governance to scale up climate-smart fodder supply?
    2.3 What factors influence the possibilities for scaling up the forage supply chain?

1.7 Conceptual Framework

Figure 2: a conceptual framework



Source: Author 2019

CHAPTER 2: FORAGE PRODUCTION AND GHG EMISSIONS

2.1 Climate change

Climate change as defined by IPCC 2011, is the persistence of anthropogenic changes in the composition of the atmosphere or in land used due to natural internal processes or external forcing's. Matthew Brander (2012) refers to Greenhouse Gases (GHG) as any gas in the atmosphere which absorbs and re-emit heat, thus keeps the planet's atmosphere warmer than it otherwise would be. Greenhouse gases (GHGs) includes; carbon dioxide (CO_2), methane (CH_4), ozone and nitrous oxide (N_2O) which are emitted during the production and transportation of agricultural commodities. Sandström (2018) argue that an increase in GHG emission is caused by human activities which are now the most pressing environmental problems facing the world's population.

For easy quantification, CH_4 and N_2O emissions are converted into CO_2 equivalents using global warming potential values (with a 100-year time horizon) of 25 and 298, respectively (IPCC 2010). According to the Kenya national climate-change action plan, NCCAP (2012), agriculture is the leading source of GHGs, accounting for almost a third of the country's total emissions. Agricultural emissions are generated largely in the form of methane (CH_4), CO2 from fossil fuel and nitrous oxide (N_2O) from crop and livestock production and management activities.

Livestock supply chains are a significant source of global greenhouse gas (GHG) emissions, and emit an estimated 7.1 Gigatonnes of carbon dioxide-equivalents per year, representing approximately 14% of all human-induced emissions as per Gerber *et al*. (2013). GHG emissions of the livestock sector are mainly comprised of methane (44%), nitrous oxide (29%) and carbon dioxide (27%).

2.1.1 Impacts of climate change in livestock

Global demand for livestock products is expected to double by 2050, mainly due to improvement in the worldwide standard of living. In Kenya according to FAO (2017), consumption of beef and milk will increase by over 170% between 2010 and 2050 – by 0.81 and 8.5 million tonnes respectively. Meanwhile, climate change is a threat to livestock production because of the impact on the quality of feed crop and forage, water availability (Rojas-Downing, et al 2017). Forage quantity and quality are affected by a combination of increases in temperature, CO2 and precipitation variation (Chapman et al., 2012). The highest emissions of greenhouse gases from agriculture are generally associated with the intensive farming systems (IPCC, 1997; Olesen and Bindi, 2002.), whereas some of the low-quality forage is used. Vellinga, et al (2013) stated that to gain insight into the magnitude of this emission, quantification of GHG emissions along various livestock production chains is the way forward.

Though the livestock generate highest emission in agriculture, Peters, M. et al, 2013 and Thornton et al. 2010 stated that livestock plays a central role in global food systems and in food security, accounting for 40% of global agricultural gross domestic product for that reasons, least 600 million of the world poor depend on income from it. Also supported by Reynolds, et al (1996) that small-scale dairy production offers a route to increase rural employment and improve household welfare.

2.1.2 Inadequate and poor quality feed.

An inadequate supply of quality feed is the major factor limiting dairy production in Kenya (Lukuyu, B., et al 2011). Feed resources are either not available in sufficient quantities due to fluctuating weather conditions or even when available are of poor nutritional quality. While the small-scale of dairy farm operations and the lack of broad-based use of modern farm technologies/ practices and improved breeds explain a great deal of the productivity gap, a notable factor is the lack of access to feed. According to Njarui, et al, (2016) across all systems, fodder availability is inadequate and prices are too high for smallholder dairy farmers to access. This is constraining their milk output and their ability to expand production. This problem is compounded by seasonal changes in pasture conditions, with poor productivity during dry seasons. High milk fluctuations arise because most farmers depend on rain-fed feed production and rarely make provisions for preserving fodder for the dry season.

2.2 Intensive dairy farming

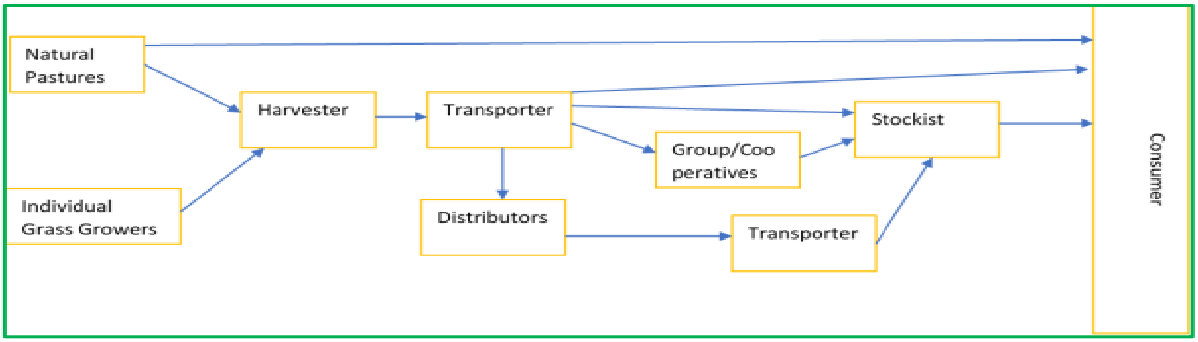
Intensive small dairy farming is the practice of confining dairy cattle in a stall and feeding them there instead of letting them graze freely in the fields. According to Odero-Waitituh, et al (2017) many small-scale dairy farmers in Kenya are adopting zero-grazing because of the several benefits associated with it. With zero-grazing, farmers can deal with challenges of insufficient land for pasture, low-quality fodder, the spread of diseases, and low productivity of dairy cattle.

2.3 Forage value chain

The fodder value chain generally varies by region, fodder type, and the kind of fodder, i.e., whether green or dry, among other factors. Napier grass has the shortest value chain, as it is generally sold directly from the producer (fodder surplus from the dairy farmer or commercial fodder farmer) to the consumer (fodder-deficit dairy farmers or dairy farmers who do not produce their own fodder) (Auma, et al 2018).

Kenya has a well-established seed company, which produces seed by contracting farmers, Kenya Plant Health Inspectorate Services (KEPHIS) is responsible for seed inspection and ensures that the seed quality is maintained to international standards. KALRO research centres dealing with pasture and forage research, produce both pasture seed and vegetative materials for on-farm research and for distribution to farmers. Other international organizations such as the International Council for Research in Agroforestry (ICRAF) also develop appropriate fodder/legumes and make seed available to farmers. (Orodho, 2006).

Figure 3: Forage value chain in Kenya

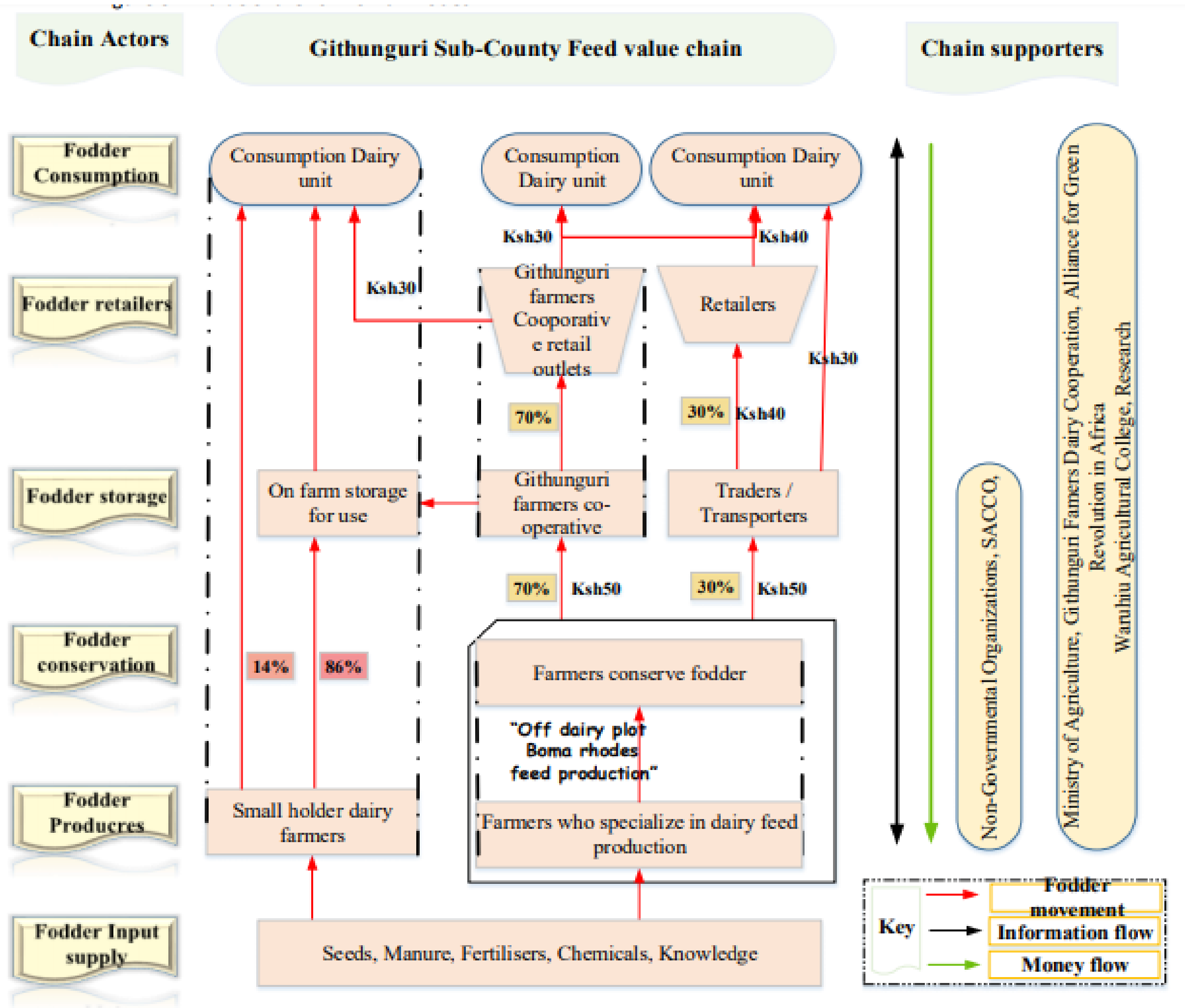


Source: Adapted from Auma et al 2018

Fodder conservation- Most farmers are doing cut and carry method of fodder feeding in Githunguri (Shumba 2018). This lack of preserved fodder exposes farmers to feed insecurity especially when feed is scarce. In addition to that, due to the high demand for forage, farmers tend to purchase whatever they get no matter the quality thus leading to less digestibility (poor quality due to lignification) increasing GHG emission. This is because farmers consider bulkiness rather than feed quality due to feed challenges they face. On the other hand, the cut and carry system is not climate-smart if Napier is left to grow to 2m.

2.3.1 Forage supply chain in Githunguri sub-county

Figure3: Boma Rhode grass supply chain in Githunguri sub-county



Source: Adapted from Shumba 2018.

Despite the availability of multiple knowledge sources, most farmers in Kenya do not have access to information on Good agricultural practices (GAP) to enhance pasture and fodder production (Kidake, B.K. et al 2016). Moreover, Mnene (2006) indicated that production of good quality pasture is influenced by good pasture establishment, management, harvesting and storage. High-quality forage reduces the requirement for commercial feeds, therefore, saving the farmer some money (Kitalyi, et al 2005).

2.4 Greenhouse gas emission

2.4.1 Land use and GHG emission

Conversion of forest to pasture or rangeland to cropland is associated with the release of GHG into the atmosphere. Organic matter above and below ground is gradually oxidized and the resultant gases CO_2 and N_2O are released. Depending on the soil characteristics management practices and climate, the pace of this development follows an asymptotic curve which is primarily very fast, practically ending after 30 to 50 years. The desertion of agricultural land or the change from cropping to pastoral rangelands or forestry leads to carbon sequestration in soil and vegetation (FAO, 2010). Sustainable farming systems should be based on alternative approaches, far beyond the use of alternative inputs, seeking an integral development of agroecosystems and low dependence on external inputs (Cuartas Cardona, et al., 2014).

2.4.2 Fertiliser application and GHG emission

Soil management systems are significant for carbon (C) sinks and to support productivity are needed to mitigate global warming; the application of synthetic fertilizers and organic manure can change soil GHG emissions, although the response differs in function of several factors such as changes in temperature, precipitation and waste composition (de Urzed et al., 2013). However, Kindred et al., (2008) mention that nitrogen (N) fertiliser can be responsible for the majority of greenhouse gas (GHG) emissions associated with the production of crops through its manufacture and N_2O emissions from the soil subsequent to its application.

2.4.3 Feeds quality and GHG emission

Feed production that releases mainly N_2O and CO_2 and enteric fermentation from ruminants (CH_4) are the two main sources of emissions, responsible for 45% and 39 % of sector emissions, respectively. Besides feed production that contributes up to 60% of total emission from animal (dairy cow), half of them coming from energy use (field operations, transport and processing and fertilizer production). GHG emissions from livestock can be reduced by one-third through efficiency improvements (Gerber et al. 2013; Mottet, A et al., 2017). Improving feed quality is considered to be one of the most effective ways of mitigating enteric methane emissions (Hristov, A.N et al, 2013).

Fodder transportation through cars and motorbikes use fuel thus contributing to climate change. Efficient cutting and carrying of fodder once in bulk with a large truck and making of silage rather than cutting it every 3 days producing GHG can lead to emission intensity reduction (Shumba 2018).

The cut and pest method of feeding livestock is not economical in energy-saving especially when the rented plot is at a distance. On the other hand, Continuous visits to the field lead to increased production of CO and CO2 thus a need to transport feed in a way that saves energy.

2.4.4 Emissions from other crops

Total emission per hectare during production for conventional, reduced tillage and direct drilling.

Figure 4: GHG emission for grains

			GHG-emissions per hectare (kg CO_2-eq. ha^{-1})		
	Yield (kg $hectare^{-1}$)	N-fertilizer (kg $hectare^{-1}$)	Conventional production	Reduced tillage	Direct drilling
Oats	3,157	77	1,800	1,720	1,720
Barley	3,380	86	1,930	1,850	1,850
Wheat	3,940	116	2,330	2,250	2,250
Rye	2,619	116	2,270	2,190	2,190

Figure 5: GHG emissions per kilo of grains

			GHG-emissions per hectare (kg CO_2-eq. ha^{-1})		
	Yield (kg $hectare^{-1}$)	N-fertilizer (kg $hectare^{-1}$)	Conventional production	Reduced tillage	Direct drilling
Oats	3,157	77	0.57	0.54	0.54
Barley	3,380	86	0.57	0.55	0.55
Wheat	3,940	116	0.59	0.57	0.57
Rye	2,619	116	0.87	0.84	0.84

Source: Rajaniemi, M., et al 2011.

2.5 Mitigation of greenhouse gas emissions

According to Kenya Climate Smart Agriculture Strategy-2017-2026, Seed companies and research centres (e.g. KALRO) should breed and promote the use of crop and forage varieties, livestock breeds, and tree species that are adapted to drought, strong winds, hailstorms, heat waves and frost as well as tolerant to emerging pests and diseases. This is through technology development, dissemination and adoption along with crops, livestock, and forestry value chains.

Chain supporter to provide efficient extension and advisory services, and improving the capacity of actors to use new or existing technologies. Also, enhance productivity and profitability of agricultural enterprises by the promotion of improved technologies; post-harvest approaches such as improved storage and distribution of agricultural products and market access. Climate-smart training needs to be incorporated in almost all farmer training and the current training platforms can be used effectively to deliver the message (Shumba 2018).

2.6 Energy consumption

Energy is very important in every stage of the agriculture system. It's very crucial in pre-production, in production, harvesting and post-harvesting operations. Energy can be direct or indirect depending on the stage of production. Direct energies include; energy from fossil fuel, mechanisation power and electricity while indirect energy includes refers to required for input manufacturing such as machinery, fertiliser and pesticides (FAO 2012)

2.7 Life cycle assessment

Life Cycle Assessment (LCA) as defined by Özeler, D., et al, (2006) as an objective process to evaluate the environmental burdens associated with a product, process or activity, by identifying and quantifying energy and materials used and waste released to the environment, and to evaluate and implement opportunities to effect environmental improvements". LCA is a methodology for examining environmental impacts associated with a product, process or service ''from cradle to grave''– from the production of the raw materials to ultimate disposal of wastes.

According to Liu, C.et al (2016), ''the major contributors to greenhouse gas emissions in crop production include the emissions associated with off-farm manufacture, transportation, and delivery of input products to the farm gate and the emissions during the crop growth period and after harvest. In the calculation, the boundaries are set for a full "Life-Cycle-Assessment" analysis''.

Calculation of energy consumption and greenhouse gas emission in accordance with IPPC 2013

Tank-to-wheels (vehicle processes): Recording all direct emissions from the vehicle transporting forage from production farms to retailers to the dairy farmers. This will be estimated by the distance and fuel consumption per unit distance e.g. Litres/kilometre. Consumption here referred to as final energy consumption.

Table 1: Emission and energy factors of fuels

FUEL	Standardised Energy Consumption (Tank To Wheel) (E_t) Mj/Litre	Greenhouse Gases Emission As CO_2 Equivalent (Tank To Wheel)-Kgco_2e/Litre
Petrol	32.2	2.42
Diesel	35.9	2.67

Source: Schmied, 2012

2.8 Chain governance

Gereffi (1994) termed Governance as a gainful consideration, which helps to transform the value chain from an experiential to an analytical concept within the firm and in the division of labour between firms. In addition, Kaplinsky, R. and Morris, M., (2000), explained that value chains imply repetitiveness of linkage interactions while governance ensures that interactions between firms along a value chain exhibit some reflection of the organisation rather than being simply random.

Value chain governance, the relationships among the buyers, sellers, service providers and regulatory institutions that operate within or influence the range of activities required to bring a product or service from inception to its end-use. According to a report from Kiiza (2018) and Shumba (2018), Githunguri Dairy Cooperative Society Ltd is a lead actor in the dairy value chain in Githunguri. 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. With their power to control the chain of forage, adoption of captive or rational governance will improve the scaling up of forage supply.

2.8.1 Type of governance

Market – refers to linkages as typical of spot markets can persist over time with repeat customers. They, therefore, do not have to be completely transitory as the key point is that the cost of switching to new partners are low for both parties.

Modular- occurs when the Suppliers make products to a customer's specifications. Buyer-supplier interactions are more substantial and sometimes very complex than in simple markets due to the high volume of information flowing across the inter-firm link, but at the same time, codification schemes can keep interactions between value chain partners from becoming highly complicated and difficult to manage. According to Shumba 2018, GDFCS only practice it on milk supply and not on forage supply.

Relational type. -The interactions between buyers and sellers are characterized by the transfer of information and embedded services based on mutual reliance regulated. Despite mutual dependence, the lead firm still specifies what it needs, and controls the highest valued activity in the chain, thus having the ability to exert more control over the supplier. ''the cooperative engages fodder growers and distributors to facilitate ease availability of quality hay to the farmers'' (Shumba 2018)

Captive type. **-** Small suppliers tend to depend on larger buyers. Depending on a dominant lead firm raises switching costs for suppliers, which are "captive." Such networks often are characterized by a high degree of monitoring and control by the lead firm. Cooperative being the lead firm in Githunguri Dairy farmers, using captive governance can able to monitor and control the forage supply to benefit the dairy farmers in terms of quality and flow of forage supply.

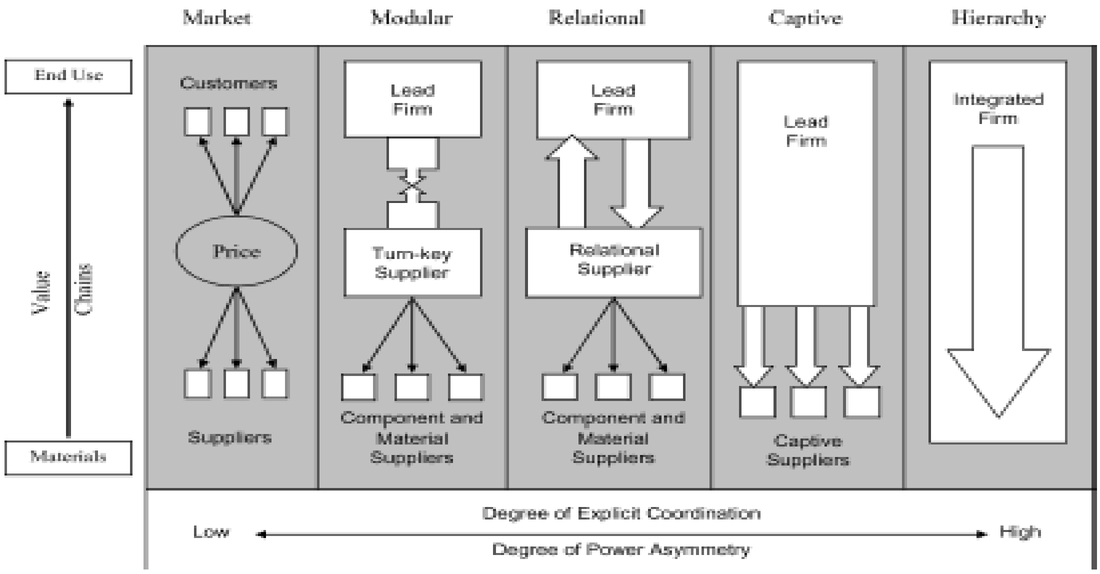
Hierarchy. This governance system is characterised by vertical integration whereby a transaction takes place within a single firm. The dominant form of governance is managerial control, flowing from managers to subordinates or from headquarters to subsidiaries and affiliates.

2.8.2 Dynamic global value chain governance

According to Gereffi et al 2005, the governance types as illustrated in Figure 5, can be used to illuminate how power operates in a global value chain. For instance, in captive global chains, power is exerted directly by lead firms on suppliers. Such control advocates a high degree of explicit coordination and a large measure of power asymmetry with the lead firm being the governing party.

On the other hand, in relational global value chains, the power balance between the firms is more balance, given that both contribute key competences.

Figure 6: Chain governance



Source: Adopted from Gereffi et al., 2005

Dynamics of value chain governance

Table 2 identifies some trajectories of change of global value chain governance. (Gereffi, Humphrey and Sturgeon, 2005) The governance types comprise a spectrum running from low levels of explicit coordination and power asymmetry between and key determinants of chain governance. When the complexity of the transaction is low and the ability to codify is high, then low supplier capability would lead to exclusion from the value chain.

Table 2: Dynamics and determinants of value chain governance

GOVERNANCE TYPE	**COMPLEXITY OF TRANSACTIONS**	**ABILITY TO CODIFY TRANSACTIONS**	**CAPABILITIES IN THE SUPPLY-BASE**
Market	Low	High	High
Modular	High	High	High
Relational	High	Low	High
Captive	High	High	Low
Hierarchy	High	Low	Low

Dynamics of changes in governance

1 Increase the complexity of transactions reduces suppliers competence in relation to new demands
2 Decreasing complexity of transactions and greater ease of codification.
3 Better codification of transactions
4 De-codification of transactions.
5 Increasing supplier competence.
6 Decreasing supplier competence.

2.9 cost of production

Total Revenue- Refers to the amount a firm receives for the sale of its output.

Total Cost- The market value of the inputs a firm uses in production.

Profit - is the firm's total revenue minus its total cost.

Profit = Total revenue - Total cost

Total Costs

TC = TFC + TVC

Whereby :

TFC-= Total Fixed Costs

TVC =Total Variable Costs

TC = Total Costs (Dierkes and Siepelmeyer, 2019)

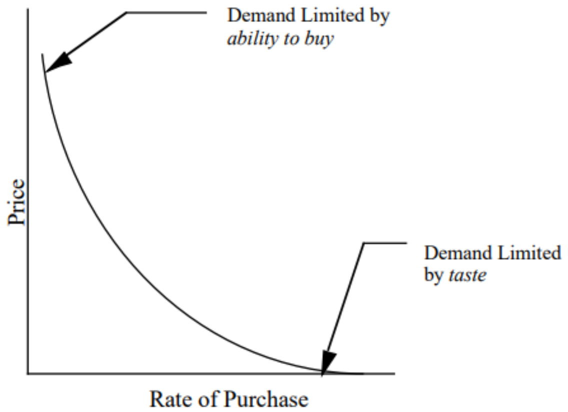
2.10 Supply and Demand

Demand refers as the quantity of a good or services customers are willing and able to buy at a different price at a certain period, whereas supply refers to how much of goods or service is offered at each price at a certain period. The time and the price of goods or the service are the key determinants, when the price increases, the willingness and ability of sellers to offer goods will increase will the willingness and ability of buyers to purchase goods will decrease (Whelan and Msefer, 1996)

Demand

Figure 6, shows a generalised relationship between the price of goods and the quantity which consumers are willing to purchase in a given time period. The higher the price the lower the rate of purchase. The simple demand curve seems to imply that price is the only factor which affects demand.

Figure 7: Demand curve

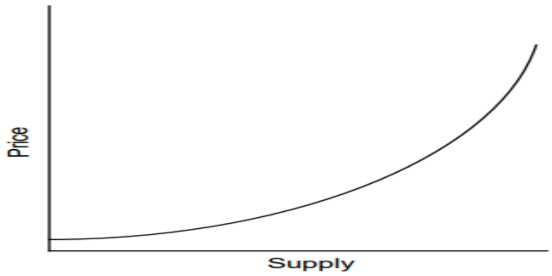


Source: Whelan, J. and Msefer, K. 1996.

Supply

The curve of figure 7, moves from downward to upward direction giving the positive factor, it shows that price is directly proportional to supply as at higher prices, more of the commodity will be available to the buyers. This is because the suppliers will be able to maintain a profit despite the higher costs of production that may result from the short-term expansion of their capacity.

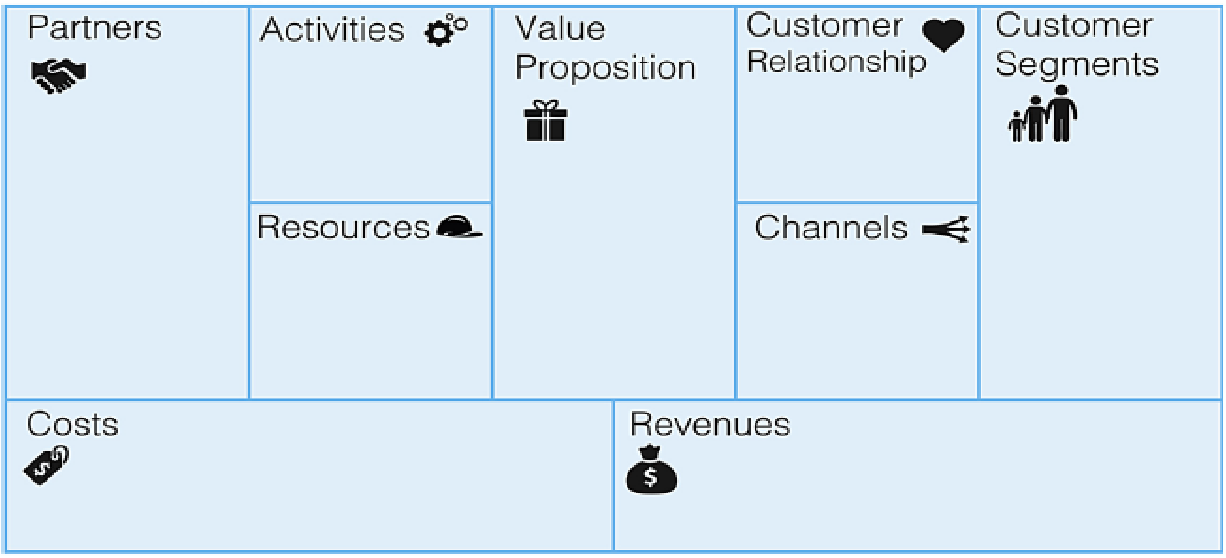
Figure 8: Supply curve



2.11 Business models

Osterwalder and Pigneur (2010) proposed a business model canvas as a tool. It presents the elements that form a building block of a business plan for a new or existing organisation. It consists of nine blocks as shown in Figure 7 covering financial crises and benefit. Due to increasing business risks, Osterwalder and pigneur (2011) developed environmental and social canvas as direct extensions of the original economic-oriented business model canvas, each provides a horizontal coherence within itself, thus integrate a view of economic, environmental and social value creation throughout forming Triple Bottom Line (TBL) business model. While criticised for simplifying sustainability by Norman and MacDonald (2004), TBL is very useful here as kit help to overcome barriers to sustainability-oriented changes within the organisations as explained by Lozano (2014)

Figure 9: Economic business canvas model



Source: Osterwalder and Pigneur (2010)

Table 3: Nine blocks of the business model canvas

BLOCK	**DESCRIPTION**
Customer segment	Refers to different groups of people an enterprise aims to reach
Value proposition	Describes the packages of product and services that create values for customer
Channels	Describe how the organisation reaches its customers to deliver the Value proposition
Customer relationship	Type of relationship an organisation establishes with specific customer
Revenue Streams	Cash an organisation generates
Key Resources	Refers to the most important assets required to make the business model work
Key Activities	Describe the most important things an organisation must do to make it's business model work
Partnership	Describe the network of suppliers and partners that make the business model work
Cost Structure	Describe all costs incurred to operate a business model

Table 4: Triple bottom line business model Canvas

<table>
<tr><td rowspan="2">Partners</td><td>Key activities</td><td rowspan="2">Value proposition</td><td>Customer relationships</td><td rowspan="2">Customer segments</td></tr>
<tr><td>Key resource</td><td>Channels</td></tr>
<tr><td colspan="3">Cost structure</td><td colspan="2">Revenue stream</td></tr>
<tr><td colspan="3">The social and environmental impacts</td><td colspan="2">Social and environmental benefits</td></tr>
</table>

Source: Osterwalder and pigneur (2011)

The environmental layered business model

The environmental layer of the TLBMC builds on a life cycle perspective of environmental impact. This stems from research and practice on Life Cycle Assessments (LCA), which is a formal approach for measuring a product or service's environmental impacts across all stages of its life.

The social layered business model

Social layer captures the mutual influences between stakeholders and the organization. Also, the key social impacts of the organization that derive from those relationships. Doing so provides a better understanding of where are an organization's primary social impacts and provides insight for exploring ways to innovate the organization's actions and business model to improve its social value creation potential.

2.12 Climate-smart practices for scaling up

Table 5: Climate-smart practices

Climate-smart practice	**Indicators**	**Mitigation practices**
Methane smartness	Reduction of poor quality feeds on dairy farms	Use of improved quality forage (protein dietary). Improving the productivity of the cows over their lifetime (fao 2013)
Carbon smartness	Reduce soil disturbance (reflected in a number of hours of tractors used and application of alternative soil management). Reduce carbon emission (mainly associated with tillage)	Agroforestry, crop rotation Use of cover crops
Nitrogen smartness	Reduce the need for synthetic nitrogen-based fertiliser (e.g. Kg/ha/year). Reduce nitrous oxide (N2O) emissions (by adopting better techniques for fertiliser use and soil management)	Application of manure in the forage field at the right time. Apply the right quantity of manure and frequent testing of soil PH.
Weather smartness	Minimise negative impacts of climate hazards such as soil degradation. Prevent climate risk through practices that allow farmers to be more prepared to mitigate climate change	Adoption of agroforestry in the forage production side and on the farm.

Source: World Bank and CIAT, 2015 (*Adapted from Kiiza 2018)*

CHAPTER THREE: METHODOLOGY

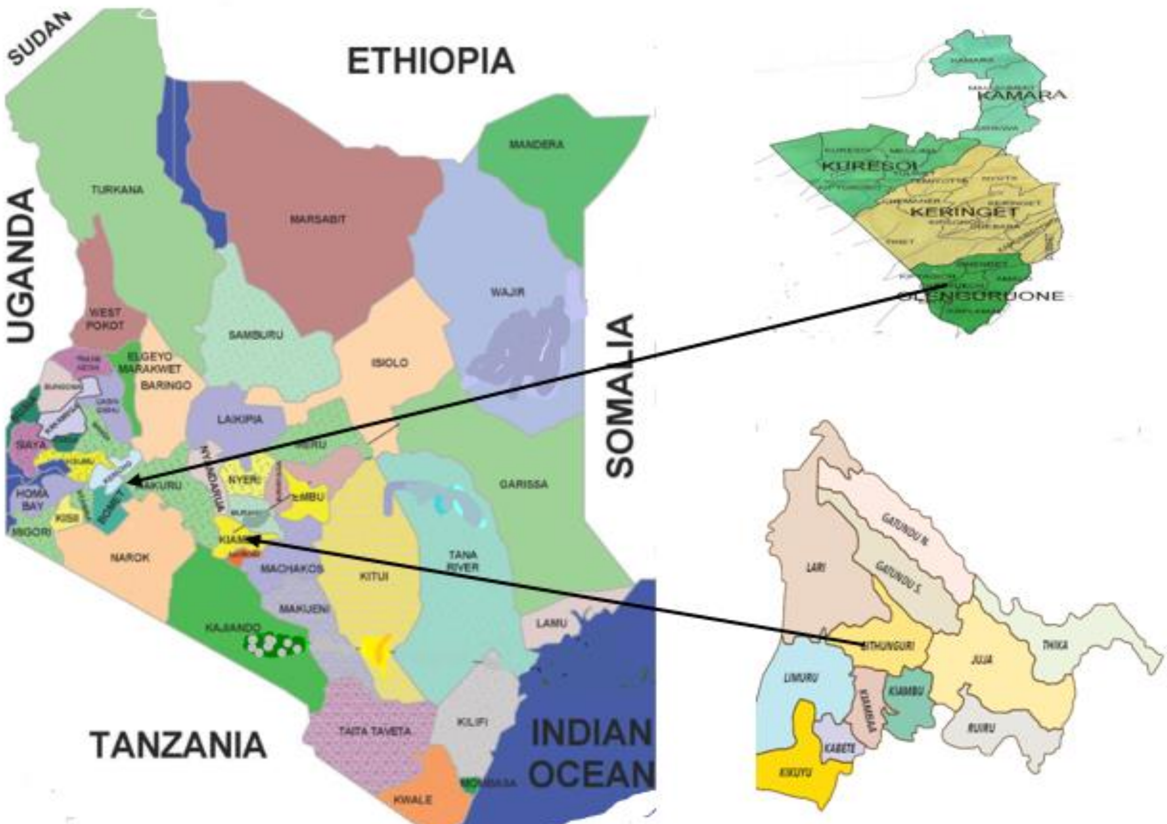
The study used both a qualitative and quantitative approach to data gathering and both primary and secondary data collection techniques. Primary data was collected between 1 June 2019 to 30th August 2019 in four different counties: Githunguri- Kiambu County, Narok East and south, Nakuru, and Ruaraka- Nairobi County. This was achieved through snowball sampling techniques.

Focus Group Discussion and key informants' interviews were conducted for various forage chain actors identified by each dairy cooperatives (officials. These chain actors include Dairy farmer, transporters, stockist (agro-vets), mobile traders, brokers, cooperatives and forage producers. Two meetings were conducted with Dairy Farmer Cooperatives, one in Githunguri and another one Olenguruone as the entry point of farmers identification and other actors. Two FGD were conducted with dairy farmers with the emphasis on quality of forage, chain governance and forage supply and demand.

3.1 Study area

The study was conducted in two sub-counties namely; Githunguri in Kiambu county and Olenguruone in Nakuru County Kenya.

Figure 10: Githunguri and Olenguruone maps in Kenya



Source: Google map 2019

Kiambu County is adjacent to North border of Nairobi Metropolitan Region. It has an urban population of 88,869 and total population 0f 1,623,282(Male – 49%, Female – 51%) and a total area of 2,543.4 Km2. The county has a warm climate with temperature ranging between 12^{0}C and 18.7^{0}C. The rainfall aggregate for the county is 1000mm each year. The cool climate is conducive for farming. The county relies on Agriculture for its economy. Majority of the residents are small-scale farmers. Githunguri sub-county is one of the 12 Kiambu sub-counties and it is an agricultural town. It is home to one of

East Africa's largest dairy processing plant Fresha, which is owned by a farmers co-operative namely Githunguri Dairy Community (GDC).

Nakuru county is one of 47 counties in Kenya and it lies within the Great Rift valley, bordering eight other counties: Baringo and Laikipia to the North, Nyandarua to the East, Narok to the South-West and Kajiado and Kiambu to the south. It lies between 00°N 35^{0}17'E, 2100-2400 metres above sea level with an average rainfall of 1836mm and temperature 10^{0}C to 28^{0}C

The county has 11 constituencies Kuresoi south being one of them and it covers an area of 7,495.1 square Kilometres (Km2) (GoK 2013).

Agriculture is the mainstay. It plays an important role in the provision of food and employment creation. Agriculture sector comprises of; livestock, fish farming, cash crop (horticulture and floriculture).

The agricultural sector comprises the following sub-sectors: livestock keeping, fish farming, food, and cash crops farming including horticulture and floriculture. Both subsistence and large-scale commercial farming is practised.

Olenguruone sub-county is in Kuresoi south one of the Nakuru constituencies. It is an agricultural production area with large scale plantation of tea and dairy farming.

Reason for choosing two areas

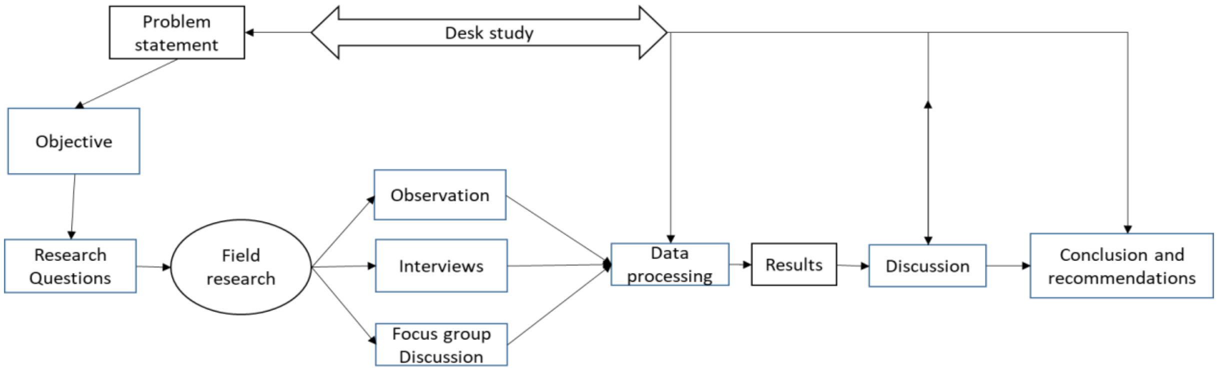
1 High potential areas that support dairy farming
2 Have well-established cooperatives i.e. Githunguri Dairy Farmer Society and Olkalou cooperatives.

3.2 Research strategy

This research will be conducted in Githunguri -Kiambu county and Olkalou Sub-county of the Nyandarua. It will have a qualitative design.

3.3 Research framework

Figure 11Research framework



3.4 Research approach

Life Cycle Assessment Approach

The Life Cycle Assessment (LCA) approach is widely accepted in agriculture and other industries as a method to evaluate the environmental impacts of production, and to identify the resource and emission-intensive processes within a product's life cycle (FAO 2010). LCA was used to quantify greenhouse gas emissions associated with forage production and supply.

In order to get an overview of fodder producers on the forage value chain, a snowball-sampling technique was applied from the purposely six selected forage consumers (dairy farmers), four from Githunguri in Kiambu and two from Olenguruone- Nakuru County. Cooperative extension officers from both dairies helped and participated in the Selection of dairy farmers (forage consumers).

Quantification of greenhouse gases emission

This study considered three different emission sources;

a) GHG emission from the fuel used during forage production and management.
b) Emission from transportation both on-farm (forage producing farms) and along the chain
c) Emission from manure and fertiliser application during forage production.

Table 6: GHG conversion table (CO2 equivalent)

GREENHOUSE GASES	GLOBAL WARMING POTENTIAL (GWP)
Carbon Dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous Oxide (N_2O)	298
Hydro-Fluoro-Carbon (HFCS)	124-14800

Source: Adapted from IPCC 2007

a. Synthetic fertilize (forage production)

Tier 1 method will be used to calculate an estimation of nitrous oxide emission from fertilizer application. This will be achieved by the following steps.

$$N_2O\ emissions = N_{fert} \times [(1 - FRAC_{atm,f}) \times \varepsilon_{\text{factor}} + (1 - FRAC_{Leach}) \times EF_{Leach}]$$

N_2O emissions = amount of N_2O emissions from fertilizer use (kg N2O).

N_{Fert}. = total use of synthetic fertilizer in Kenya, (kg N/yr). (Kuyah S et al 2017).

b. Emission from transportation

Emission from Energy consumption:

Using tier 1 formulas in accordance with IPCC, (2013)

GHG emission = 0.001 * Fuel Usage * High heat value *Emission factor or GW = F x gW GT = Tank-to-wheels GHG emissions in kg CO2 equivalents (CO2e).

The greenhouse gas emissions will be calculated as CO2 equivalents. In addition, energy consumption will also be calculated and presented in a standard way in MJ.

ET = F x eT

ET = Tank-to-wheels energy consumption in MJ

F: = Measured energy consumption (e.g. l, kg or kWh)

eT = Tank-to-wheels energy factor from measured values in MJ *c. Emission from fuel consumptions*

The greenhouse gas emissions for tank-to-wheels (fuel consumed per unit distance) are calculated in a similar way to energy consumption. A specific conversion factor is used to multiply the measured energy consumption for both values (Shem Kuyah et al 2017)

GT = F x gT

GT = Tank-to-wheels GHG emissions in kg CO2 equivalents (CO2e)

F: = Measured energy consumption (e.g. l, kg or kWh)

gT = Tank-to-wheels GHG emission factors from measured values in kg CO2egW = Well-to-wheels GHG emission factors from measured values in kg CO2e

TTW energy consumption: ET = F x eT = 406 l x 35.9 MJ/l = 14,578 MJ

TTW GHG emissions: GT = F x gT = 406 l x 2.67 kg CO2e/l = 1,08

d. GHG emissions from manure

GHG and NH3 emission from manure are estimated based on reference management practice reported by Aguirre-Villegas and Larson (2017) as shown in the table 5.

''Feedlot cattle can generate manure about 5–6% of their body weight each day, a dry mass of roughly 5.5 kg per animal per day. Full-grown milking cows can produce 7–8% of their body weight as manure per day, roughly a dry mass of 7.3 kg per animal per day.'' (Font-Palma, 2019)

Table 7: Manure GHG emissions

Process	Management practices	NH3 gNH3/tonne	GHG manure gCO2-eq/ton	GHG energy gCO2-eq/ton	Total GHG gCO2 –eq/ton manure
Land application	Surface application, no storage	1,583	28,075	5,503	33,579
Land application	Surface after storage. No agitation	1,211	14,244	2,169	16,413
Land application	Injection after storage	24	12,061	11,510	23,572

Source: Aguirre-Villegas and Larson, (2017)

3.4.1 Research Boundary

The assessment was carried out only on forage supply chain (silage, wheat straws, Rhode grass hay, Lucerne hay, maize stovers), dairy concentrates were excluded. The information was gathered from different chain actors through observations, interviews and focus group discussions. The system boundary was split into two sub-systems:

1. Cradle to farm-gate includes all upstream processes in forage production up to the point where the forage leaves the farm, i.e. production of farm inputs, and forage farming.

2. Farm-gate to forage consumer (intensive dairy farmer)- Covers transport and cost along the chain to the end consumer.

At the forage production level, inputs of fertilizers, fossil fuels, and agricultural machinery were assessed. Background data for the production and emissions of these inputs were derived from databases guided by IPCC, (2013).

3.5 Data collection

Both primary and secondary data were collected. Snowball sampling techniques were used to map up the forage value chain. Observation, interviews and Focus Group Discussion techniques were used to gather primary data, while books, journal and internets were used to gather secondary data.

3.5.1 Desk study

A desk study was conducted to gather relevant literature from secondary data sources such as publications books, journals, reports, and reliable online sources such as Greeni, Google scholars, among others. This helped to gain an in-depth understanding of research areas, forage chain supply, GHG emissions, chain governance and business models.

3.5.2 Observation

Observations were conducted during an interview with dairy farmers, stockist, transporters and forage producer to gather supportive information guided checklist. The observation method helped to identify best methods used by the forage chain actors to preserve forage, transportation, technologies and resource used along with the forage

3.5.3 Interviews

Interviews were conducted to gather information from the forage chain actors and the key informants. The interviews were relevant for collecting both qualitative and quantitative data.

1). Chain actors

In Githunguri and Olenguruone dairy societies, different chain actors were interviewed. The interviews were conducted only to farmers who are the members of the cooperative societies. In Githunguri, interviews were conducted to four different intensive dairy farmers, three stockists (agro-vets), one supplier, two transporters, two brokers, three hay producer and two food manufacturers (waste materials). The interviews were guided by open-ended questionnaires and checklists (Appendix 1) with the aim of collecting data on a key aspect such as experience about climate change, chain governance, forage value chain, cost, and quality of forage sustainability of forage production and supply and future expectation.

2). Key informant interviews

The interviews were relevant for collecting quantitative data in both areas of study. These were guided by a well-tailored checklist. Respondents from Githunguri area were in this regards included Head of extension of Githunguri Dairies, head of purchase and supply department Githunguri dairies, extension officer from Ministry of Livestock, Agriculture and Fisheries (MoLAF) Githunguri sub-county, head of environmental department -technical university of Kenya, Kenya seed company, research officer - KALRO and Egerton university. Also Extension officer from Kuresoi Sub-county, Head of the extension officer Olenguruone Diary society, SNV representative and the lead farmer Olenguruone. The checklist helped to guide interview on the key aspect such as the production of forage and climate change, operation of the forage value chain, chain governance, government policies concerning forage production and supply, the sustainability of the dairy industry and general information of forage in the research areas.

3). Focus group discussion

The focus group discussion was organised at county pride hotel is near Githunguri town. A total of 17 respondents participated, these include; 8 smallholder dairy farmers, two representatives of Githunguri SACCO, and four extension officers from Githunguri Cooperative and Ministry of Agriculture, Livestock and Fisheries as shown in *Table 8*. The discussion sought to collect in-depth data on forage chain governance, chain actors' relationships, business models, scalable practices, challenge and opportunities for adopting climate-smart practices.

Table 8: Summary of Data collection

Area of study	**Githunguri**				**Olenguruone**			
Participants	Forage producer	Suppliers And brokers	Retailer & transporter	Consumers	Forage production farmers	traders	Retailers	Consumers
Chain actors	5	3	5	4	2	3	2	3
FGD				14 farmers				8 farmers
Key Informants	Kenya seed co. C.L.D extension officers	GDFCS extension officer	lecturer-technical university of Kenya	KALRO Research officer	Egerton University	CG extension officer	extension officer	KALRO research officer

Source: Author

3.6 Methods of data analysis

Research findings were analysed using three different methods namely; Grounded theory, Life cycle analysis (LCA) and Value chain analysis. The methods are described below.

3.6.1 Value chain analysis

VCA was used to identify stakeholders (actors and supporters) along the forage production chain. It was also used to calculate the cost of production and gross margins along the forage supply chain. Rhode grass hay was used as the main forage during calculations. Hay bales were chosen because they are easier to estimate the cost of production as indicated by Kenya Crops and Dairy Market Systems (KCDMS) survey report (2018), also Rhode grass hay was the main forage used in the area. According to KCDMS, Boma Rhodes yield per hectare per year is approximate 6.7tons, Bracharia sp 8.6ton/ha, Desmodium 5.4 ton/ha and sweet potatoes vine gives 20.3 tons/ha.

Gross margin analysis

Gross margin analysis was tabulated using the excel spreadsheet according to the characterisation of the variable cost-revenue structure to find the cost of production.

Gross margin was used to analyse the benefit share and added value of collectors, transporters and retailers along the forage value chain. The gross income for each actor was estimated by subtracting the cost price of the product/unit from the sale price (revenue) of that product as per (KIT and IIRR, 2008):

3.6.2 Grounded Theory data processing

Different analytical tools were employed for data processing qualitative data. Interviews, observation, voice or video recording and documents were analysed using the grounded theory method. Stakeholders matrix and mapping was used to describe the chain actors along the forage supply chain. And CANVAS Business Models were developed to present, recommend profitable and sustainable business operations for a forage supply chain that benefits the intensive dairy farmer in Githunguri.

For the Grounded Theory method, the following steps were taken during the data processing after data collection; all information will be transcript;

The data were organised into segments and label.

a) Relevance: pick all relevant information for study (filtering) and the rest removed.
b) Open coding: the segmented information will be scrutinised for commonalities and comparisons.
c) Axial coding: The related labels with specified properties and dimension was grouped into subcategories.
d) Selective coding: All subcategories will be grouped around the core categories related to the research dimension

3.6.3 Life cycle analysis (LCA)

LCA was used to evaluate and estimate GHG-emissions from the production of forage and transportation along the chain to the end consumer. LCA was based on:

CO_2 produced from the combustion of fuel used during forage production and transportation within the farm (forage producing farms)

CO_2 produced during transportation along the chain from the forage producers to forage consumers (Intensive dairy farmers)

N_2O produced from synthetic fertilisers and manures used during forage production.

Table 9: Summary of data collection and tools of analysis

Research Questions	Method of data collection	Methods of analysis
The forage value chain	Interviews, desk study	Value Chain Analysis
Forage production, GHG emission and scaling up of forage value chain	Observations Interviews and desk study, Focus group discussion	Grounded theory
Greenhouse gases quantification	Observation, interviews	LCA analysis

CHAPTER FOUR: RESULTS

Discussed under this chapter includes three main components: value chain analysis, data for grounded theory development and data for Life Cycle Analysis

4.1 Introduction

In this chapter, the findings of the interviews and observations conducted for the case of the forage supply in Githunguri and Olenguruone were presented. Quantitative data were processed using Ms Excel version 10 and results were presented in appropriate tables and figures. Qualitative data was processed and presented in narrative form. Tables, figures and models were developed to give clear analysis.

4.2 Forage Value chain

The forage value chain gives basic overviews, the main actors, locations and positions of different stakeholder, support services and enabling environment along the chain.

4.2.1 Forage production and conservation techniques

This section presents forage available in the area of research both locally produced and external sourcing. Table 8, shows the type of forages dairy farmers from Githunguri and Olenguruone dairy societies are using. The table also shows the immediate source and area of production.

Table 10: Type and the source of forage

Study area	Available dairy feed (forages)	Current source	Area of production
Githunguri sub-county (Kiambu County**)**	Type of pasture/fodder Napier grass Natural grass –Kikuyu grass and cough grass Maize silage Rhode grass hay Rice straws hay Wheat straws hay By-products Pineapple waste Breweries waste	Own farm Farmer-farmer Roadsides Agrovets-(stockist) Cooperative stores/Traders Commercial large-scale farms	- Githunguri area - Narok North - Narok west – Ngorengore - Nanyuki - Mwea irrigation scheme -Nakuru-Ngongongeri farm - Kiambu Kenfine farm - Thika –Delmonte - Ruaraka –Nairobi
Olenguruone Kuresoi south- (Nakuru county)	Napier grass Sweet potato vines Calliandra Sesbania Leucaena Maize silage and maize stover Rhodes grass Nasiwa Nandi seteria Columbus grass Kikuyu grass Other (Oats)	Farmer to farmer Agro vet (Stockist) Traders (hawkers) Specialist small scale farmers Commercial large scale farmers	Olenguruone Rongai/ Njoro Egerton university Lalela farm- Narok

Source: Author 2019 (Fieldwork)

4.3 Description of the Forage value chain

This section gives the overview description of forage supply chain as shown in Figure 14 and 15. It provides the roles of chain actors and supports.

4.3.1 Chain actors

Input suppliers

Input suppliers operate at the start of the forage value chain, they provide goods and services such as seeds, fertilisers, farm machinery and equipment, extension service, financial service among others. Input suppliers include Agricultural input deals, Agro-vet, Dairy cooperatives, financial institutions and Government institutions (Kenya seed company, KALRO, MoALF).

Forage producers

These are farmers who grow forage either for feeding their own dairy animals or to sell fresh or preserved. It was observed that small-scale dairy farmer produce forage for their own dairy animals and sometimes sell to their neighbours, however, they contract the service providers during forage establishment and harvesting. Large-scale farmers produce forage for commercial purposes, the majority own their farm machinery while others do partial contractual service.

Storage and preservation techniques

It was observed that most large scale producers do not have storage facilities, they bulked them in the field and cover with the polythene paper as in Figure 17 No.1**,** it also observed that others have old stores with a leaking roof (No. 2) and not well covered. Some have well-structured stores (Fig 12, No 3).

Figure 12: Type of storage facilities and techniques

1). ***2).*** ***3).***

Forage traders

Informal small trader, brokers, hawkers, hay producers and few formal large-scale traders dominate forage traders within the forage value chain. It was observed in Githunguri that, small stockists/ agro-vets dominate the market similar to Olenguruone. Due to small land sizes in Githunguri, small-scale farmers tend to buy forage throughout the year but less during the rainy season. Unlike Olenguruone where dairy farmers buy forage only during the dry season.

Storage facilities at traders' level

Traders in Githunguri including Githunguri Dairy Cooperative society have well-structured storage facilities along the main roads and route as categorised by the cooperative society. Unlike Githunguri, Olenguruone cooperative does not have stores for forage, however, few traders who are dealing with forage business have small stores.

Brokers

They are involved in the transaction between smallholder farmers and forage traders. They are the linkers of forage traders, producers and the consumers (dairy farmers). Based on interviews with forage traders and transporters, brokers players a key role in terms of pricing and information flow.

Transporters

These are the owners of motorists and trucks. They are involved in transporting forage from the production sites to the centre of the business where the forage is awaiting to the consumption point. Also from the point of business to the dairy farmer (consumption point). They charge for their service based on the distance or per bale.

Cooperative

Dairy Farmers Cooperatives are the smallholder farmer own dairy cooperatives. In a forage supply chain, Githunguri DFCS involved as the lead actor. The cooperative source the Rhode grass hay mainly from large- scale hay producers, store them and supply to their members through the cooperative outlets. Dairy farmers purchase the hay through the check-off system or by cash.

Olenguruone cooperative is not involved directly in the forage supply chain but offering other service related to the forage chain. They collaborate with county livestock department, SNV (Netherlands Development Organisation) and Smallholder Dairy Commercialisation projects to train farmers on forage production, conservation and utilisations.

Customers/ Consumers

Customers at this point are dairy farmers both small and large-scale dairy farmers. During Focus Group Discussion, the majority admitted that farmers from Githunguri have small land sizes, therefore the highest percentage of animal feeds come from other areas as illustrated in Table 8. In Olenguruone, few dairy farmers who keep their animals under the intensive system are the main customers but due to prolonged droughts, other farmers are now buying.

Storage facilities and techniques

It was observed that farmers in both study areas (Githunguri and Olenguruone) do not have storage facilities specifically for forage. Most farmers in Githunguri rely on Githunguri cooperative stores since they have been placed close to them.

4.3.2 Challenges in Forage chain

Table 11: the challenge in the forage value chain

Actors	**Challenges**	
Dairy farmers	Price fluctuation The high cost of feeds Poor quality forage Seasonality Prolong draughts	Waste management problems (disposal challenges) Lack of trust between farmers
Transporter	The high cost of fuel Poor infrastructure. Lack of storage facilities Unpredictable weather, raining during transportation Unreliable customers	
Agrovet /stockists/traders	High competition in the hay business High risk due to fire hazards	Unreliable sources Seasonality

	Lack of storage facilities	
Cooperative societies	Financial constraint The high cost of facilities maintenances Unreliable forage produces	Lack of forage experts Lack of flexibility Corruption Poor management.
Forage producers	Climate change The high cost of farm inputs especially fertiliser Unreliable rain patterns Poor soil fertility/land degradation. High initial cost per hectare Pest and diseases. Poor infrastructure/ road networks.	Lack of machinery. The high-interest rate for loans. Lack of access to finance for production Lack of government support. Lack of other services like extension services.

4.3.3 Chain supporters and enablers

Table 12: chain supporters

Chain supporters	**Actor**	**Role**
Research institutions	Kalro Learning institutions –Egerton university International Livestock Research Institutes (ILRI)	Provision of forage research services through training to farmers directly or through cooperatives
Government of Kenya	Ministry of Agriculture, Livestock and Fisheries	Provision of extension and advisory services to farmers; involved in research and development; coordination of dairy activities.
	Kenya Bureau of Standards (KEBS)	Product standardization and certification
Non-Governmental Organisations NGOs	SNVs	Provision of training to dairy farmers
Financial Institutions	Sacco's- Githunguri Sacco and Mavuno Sacco Banks- KCB, Cooperative and Micro-finances –Kenya women	Provides credit and other financial services to dairy farmers

4.3.4 Chain governance

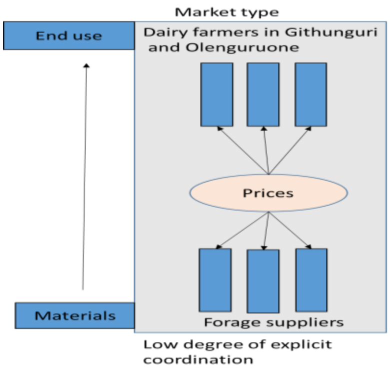
Cooperatives are the lead actors in the dairy value chain. They work hand in hand with the relevant Governing bodies and the Non-Governmental Organisations as well as private sectors to ensure that the dairy farmers are well taken care of. Through Annual General Meetings, Board of Directors in consultations with farmers sets the operating standards of the cooperative especially the type and the quality standard of the feed and forage. For Githunguri Dairy Cooperative through appointed committees and stores department, forage is sourced and supply to the stores closer to the dairy farmers where they can access.

4.3.4.1 Type of chain governance

The market type of forage chain governance was observed in both areas of research, Githunguri and Olenguruone. In Githunguri, both formal and informal forage value chain was observed. In the formal value chain, the majority of registered farmers tend to buy forage from cooperative stores either through the check-off system or cash payment, guided by by-laws. During Focus Group Discussion, farmers indicated that not all farmers buy from cooperative but the majority buy from private stockists and roadside traders. There is no formal binding agreement between actors and the mode of transaction is through either cash payment or check-off system.

In contrary, interviewed farmers and extension officer indicated that cooperative society in Olenguruone is not involved in purchasing and selling forage to their members. Farmers purchase forage from their fellow farmers or from traders. There is no formal binding agreement between them.

Figure 13: forage chain governance



Source: adapted from Gereffi et al 2005

4.4 Forage value chain Maps

Data regarding aspects such as type of forage, actors, prices, product and information flow under Githunguri and Olenguruone dairy cooperatives were collected and presented in form of value chain maps as shown in figure 14 and 15

Figure 14: forage value chain in Githunguri- Kiambu

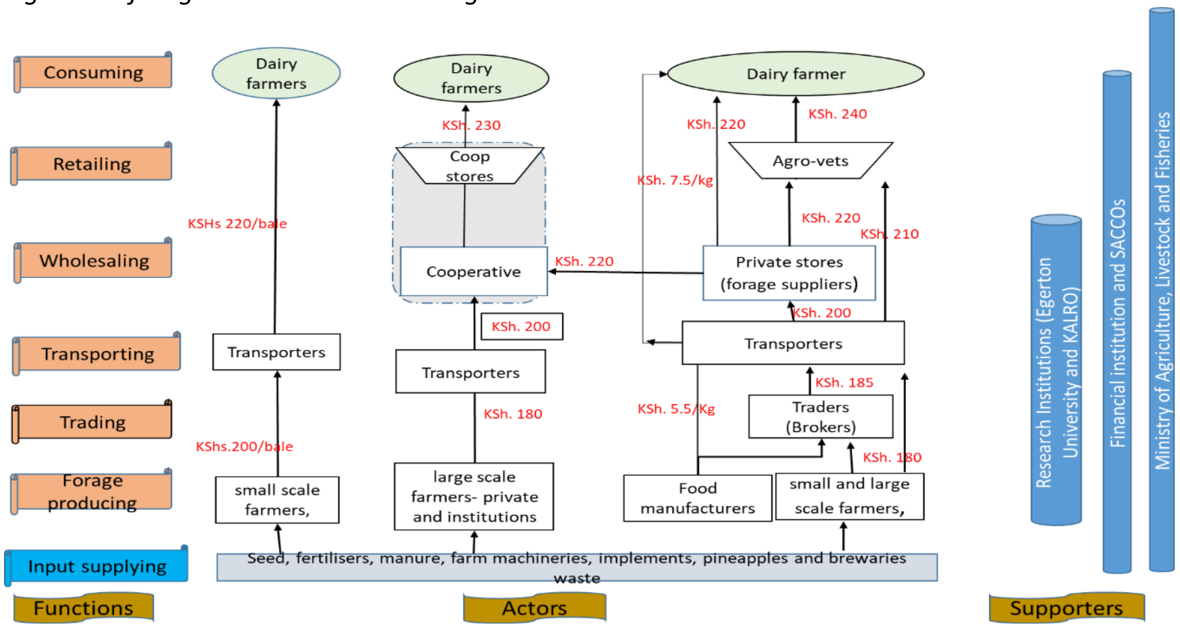
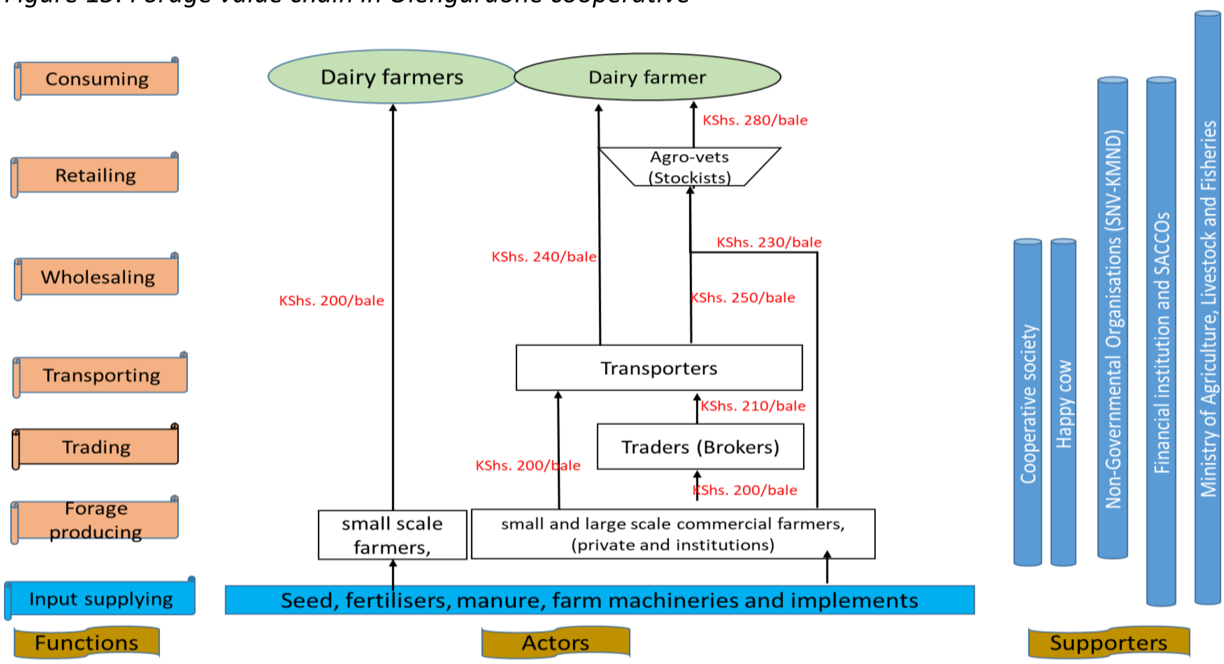


Figure 15, shows the value chain of Rhode grass in Githunguri. The chain illustrates three main channels where dairy farmers get their forage. According to the respondents, farmers buy forage from the cooperative stores through the check-off system or by cash. However, according to findings from interviews, focus group discussion and observations, the forage value chain is different from the milk value chain. It was observed that price varies depending on the type of forage. The Rhodes grass hay rate high follows by wheat straws hay and rice straws hay were the lowest.

Figure 15: Forage value chain in Olenguruone cooperative



As per figure 16, Olenguruone forage value chain has only two channels, Olenguruone Dairy Farmers Cooperative do not supply forage to their members, unlike Githunguri cooperative whereby they supply their members with forage such as Rhodes grass bales. Farmers buy forage only during the dry season from either their fellow farmers, roadside traders, agro-vets (stockists) or from the large-scale producers.

4.5 Chain analysis

Through the different interviews with forage chain actors, data collected were organized and analysed in a way of strength, weakness, opportunities and thread. Data on stakeholders was also organised and analysed based on their roles and influence to the forage chain

4.5.1 Forage value chain SWOT analysis.

Strength	**Weakness**
increase demand for dairy products ready market favourable production potential high return potential high supply potential conducive fiscal policies at the macro level	Lack of proper regulations for forage quality High transport cost Uncertified seed with poor germinations rates Underdeveloped forage value chain Poor infrastructures Limited knowledge of forage production and management Insufficient extension service High-interest rates for credit Low skills to produce and preserve quality fodder Lack of loyalty between value chain actors. High level of fragmentation along the chain
Opportunities	**Threat**
Employment opportunities in forage production and supply Large areas of underutilised land in Kenya High potential for improved forage (a mixture of other legumes like desmodium). Growing demand for dairy products due to growing middle class in Kenyan cities. High demand for forage Contribution of ecosystem service such as improving soil cover sequestering	Changing Climate patterns Poor quality of inputs (uncertified seed and overuse of synthetic fertilisers). Unreliable rainfall patterns. Poor rural infrastructure Diseases and pests Reducing land sizes

4.5.2 Cooperatives SWOT analysis

Table 13: SWOT analysis of Githunguri and Olenguruone cooperatives

Strength Loyal members Good reputation, positive image and brand names Skilled staffs both management and extension officers A ready market for their products and services Well established SACCOs Established team and teamwork High level of board and members confidence The flexibility of the product mix	**Weakness** Inflation forcing members to seek cheap financial assistance from other financial institutions Low consideration in forage quality. Closed membership Low level of inclusiveness at the management level. Most members are net borrowers
Opportunities The high demand for forage from members Advancement of technology e.g. use of mobile banking	**Thread** Climate change. Ageing membership.

Job opportunities Potential to attract new members especially youths and women Education and training to members Improve the quality of their core businesses Sustainability of the dairy sector	Lack of interest in youth to venture to the dairy business. Decrease land sizes Decrease land fertility Increase the level of inflation

4.5.3 Stakeholder analysis

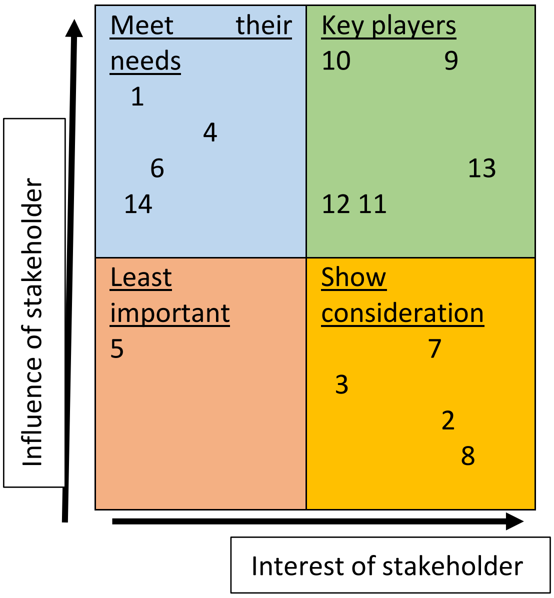
Stakeholders are people or a group of people affected by the impact of an activity related to foraging. People who can influence the impact of activity in forage chain.

Table 14: Stakeholder analysis

Stakeholders	**Roles**
Dairy farmers	Consume forage
Dairy cooperative	Purchase forage for their members
Input suppliers	Supply inputs such as chaff cutters, fertilisers, seed and farm machineries
Forage transporters	Distributes forage to dairy farmers and retailers
Forage suppliers	Contracted forage suppliers by the cooperative
	Private forage suppliers
Forage producers	Plant forage with the intention of selling to other farmers
Chain supporters/ enablers	Roles
Saving and Credit Cooperative Organisations (Saccos)	Provide credit facilities and other financial services to members.
Dairy Cooperative Societies	Provision of extension service to their members
Ministry of Agriculture Livestock and Fisheries	Provision of extension and advisory service.
Financial institutions and micro-finance	Provide the financial solution such as credit facilities and
Kenya Plant Health Inspectorate Service (KEPHIS)	Provisions of certificates for planting materials, production and trade of seeds.
Kenya Bureau of Standards (KEBS Kenya Bureau of Standards (KEBS Kenya Bureau of standards (KEBs)	Quality assurance
NGOs –SNV	Provide training to forage, producers and dairy farmers,
USAID-KAVES	Farmers capacity building and market facilitation
Kenya seed company (KSC)	Provision of certified forage seeds
Research institutions (KALRO and Egerton university)	Disseminate new technologies related to forage production and training

4.5.4 Stakeholders' matrix

Table 15: stakeholders' matrix



stakeholders

1. MoALF
2. NGOs -SNV
3. USAID-KAVES
4. Financial institutions
5. KEPHIS
6. Kenya Bureau of Standards (KEBS
7. KALRO
8. KSC
9. Dairy farmers
10. Dairy cooperative
11. Input suppliers
12. Forage transporters
13. Forage producers
14. SACCOs

Source: Author design

Key

Key player- chain actors
Show consideration –service providers
Meet the needs- enablers
Least important - others

4.6 Business model canvas

The primary data collected during the interview with the stores' department of Githunguri dairy cooperative society were used to design the business model of Rhode grass hay as illustrated in table 15. While in Olenguruone Dairy Cooperative, business model as shown in table 16 was designed during Focus Group Discussion and interviews with Olenguruone cooperative officials.

Table 16: forage Business model in Githunguri cooperative

Partners	***Key activities***	***Value proposition***	***Customer relationships***	***Customer segments***
Ministry of Agriculture Livestock and Fisheries SACCOs KALRO Forage producer	Education and training to farmers Source forage for their members Linking farmers to other experts	High-quality forage. Knowledge support	Loyalty Commitment	Githunguri dairy farmers
	Key resource Storage facilities Human resource Dairy farmers SACCOs		***Channels*** Githunguri Cooperative outlets Farmers training Field days	
Cost structure Transport cost -Staff Salary and wages Storage maintenance			***Revenue stream*** Sales of Rhode grass hay	
The social and environmental impacts GHG emission through forage transportation Depletion of land fertility			**Social and environmental benefits** Climate-smart practice Awareness creation Reduction of carbon footprint	

Table 17: Olenguruone forage business model

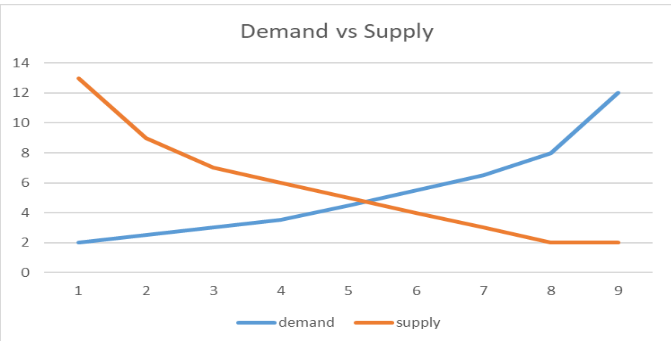
<table>
<tr><td rowspan="2"><u>Partners</u>
County livestock department
SNV
Forage producer
Smallholder dairy commercialisation projects</td><td><u>Key activities</u>
Education and training to farmers
Source forage for their members
Linking farmers to other experts</td><td rowspan="2"><u>Value proposition</u>
Improve fodder and forage production
Knowledge transfer</td><td><u>Customer relationships</u>
Loyalty
Commitment</td><td rowspan="2"><u>Customer segments</u>
Olenguruone dairy farmers</td></tr>
<tr><td>Key resource
Human resource
Dairy farmers
SACCOs</td><td>Channels
Lead farmers (field experimental)
Farmers training
Exhibitions
Field days</td></tr>
<tr><td colspan="3"><u>Cost structure</u>
Project facilitation - Labour cost
Staff Salary - Seedling</td><td colspan="2"><u>Revenue stream</u>
Sales of milk</td></tr>
<tr><td colspan="3">The social and environmental cost
GHG emission through forage production and transportation</td><td colspan="2">Social and environmental impacts
Climate-smart mitigation practice
Awareness creation</td></tr>
</table>

Source: Author

4.7 Demand and supply of forage

During Focus Group Discussion in Olenguruone dairy cooperative society, farmers agreed that it's only during the dry season when the demand is high but the supply is low. While in Githunguri where the cooperative stock forage for their members, farmers also experience the same challenges.

Figure 16: Demand and supply graph



Source: author

Quality of forage versus the quality

Price of hay bales

Farmers in both areas of study are not buying forage during the rainy season. Interviews carried out with traders and producers, indicated that the demand of hay bales is high during dry seasons and the supply at that period is low as shown in Figure 16, forcing the prices to elevate gradually. During wet seasons, the hay bales are plenty, the prices at that period are low, and quality is likely to be high.

Figure 17: Quality versus Prices of forage

Quality of hay

According to two key informants, farmers are not buying forage based on the quality, but the quantity. In most cases, the prices are determined by demand. The higher the demand the higher the prices. Based on Figure 17, (**see Annex 3** during harvesting periods, price is low per hay bale and quality is high but the demand is low since farmer at that period has enough forage.

4.7.1 Capacity of forage producers to meet forage demand (Githunguri)

Table 18: Forage production per hectare

Farm	*Farm size (ha)*	*Average of hay/hectare #bales*	*Weight per bale (Kg)*	*Total production per season kg Initial stage*	*Total production/year*
F1	112	528	15	59,136	118,272
F2	220	480	14.7	105,600	211,200
F3	291	600	15	174,600	349,200
F4	180	492	15	88,560	177,120

Source: Author 2019

4.8 Cost of production, for forage production

The cost of production was consolidated from different production farms during interviews. The cost was calculated based on one hectare of two different farms, the farms with agricultural machinery and the other one without machinery. The calculation gives the cost of different activities (see table 19) at the first season of forage (Rhode grass) establishment and the second season after establishment.

Table 19: cost of Small and medium forage production (Rhodes grass).

	FARM 1 (OWN MACHINERIES)		FARM 2 (CONTRACTED SERVICE)	
ACTIVITIES	*cost of production crop establishment/ ha (KSHs)*	*cost of production (established crops)/ha (KSHs)*	*cost of production establishing crop/ ha (KSHs)*	*cost of production established /ha*
Ploughing	1815.45	0	8645	0
1st Harrowing	2074.8	0	3705	0
Raking	1296.75	0	2470	0
Labour	15808	8645	17290	10374
2nd Harrowing	2074.8	0	3705	0

Planting	1296.75	0	2470	0
Fertiliser(250kg/Ha)	14820	7410	14820	7410
Seeds (10kg/Ha)	9880	0	9880	0
Compaction	1556.1	0	2470	0
Weeding	1037.4	8645	8645	8645
Harvesting	6743.1	37050	29640	37050
Total Variable Cost	**83,103.15**	**61750**	**103,740**	**63479**
Yield per hectare	494	617.5	494	617.5
Average /kshs/bale	220	220	220	220
Total revenues	**108,680**	**135,850**	**108,680**	**135,850**
Gross margin	19.7%	52.3%	2.15%	52.1%
Fixed cost*	4,155.20	3,087.5	2593.5	1,587
Net profit/ha	**21,421.65**	**71,012.5**	**2,346.5**	**70,784**

NB: the Fixed cost was calculated at an average of 5% of the total variable cost for the farm with machinery while for the farm without was calculated with an average of 2.5%

Cost of hay bales per season for a farm with their own machinery

Total cost per bale at first season of establishment

Cost /bale= Total variable cost + fixed cost/No. of bales produce

Where:

Cost/bale= (83103.15+4,155.20)/494 bales

Cost per bale KShs. 176.60

Equivalent to KShs. 11.77 per kilo (1 bale=15Kg)

Second season after the establishment

Cost = (61,750+3,087.5)/617.5 bale produce in one hectare at average of KShs.220

Cost per bale= KSHs.105

_Cost per Kg KShs. 7

Cost of hay bales per season for the farm without their own machinery (Contracted service)

The first season of establishment

Cost /bale= Total variable cost + fixed cost/No. of bales produce

= (103740+2593.5)/494 bale

Cost per bale KShs. 215.25

Cost per kg KShs. 14.35

The second season after the establishment

= (63,479+1,587)/617.5

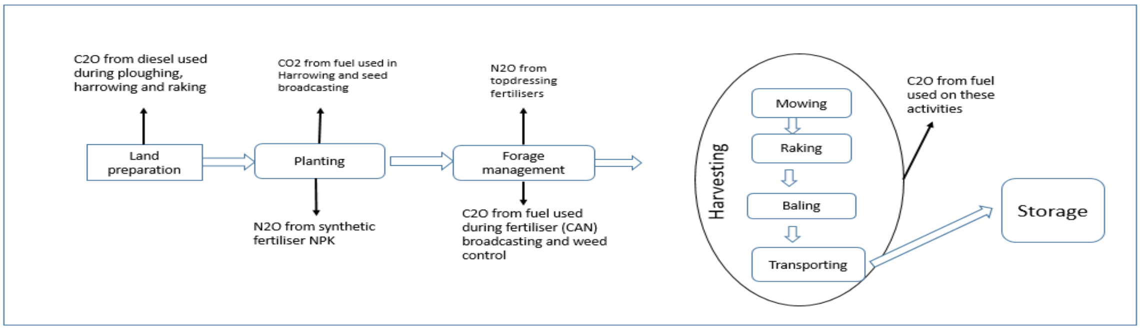
Cost per bale KSHs. 105.37

Cost per Kg KShs. 7.

4.9 Quantification of Greenhouse emission

The quantification and analysis of GHG emission use Life Cycle Assessment approach (LCA) for identification of main emission sources along forage supply chain, starting from land use as shown in Figure 18, and the production to the transportation of forage to the farm gate (dairy farmer). The major GHGs emitted from forage chain are covered –N_2O, CO_2 and CH_4.

Figure 18: the source of GHG emission at farm level (forage production



Source: author

The quantification of GHG emission and energy consumption was based on one hectare per season.

4.9.1 Emission during hay production

The calculation of GHG emission associated with agricultural vehicles and other farm machinery, the following factors were applied:

Fuel Type	Emission Factor (KgCO_2 Per Unit Fuel (Litres))
Diesel	2.67
Petrol	1.67

Therefore, KCO2=total litres of fuel used by fuel factor.

According to the research findings from different interviews with forage producers, the consumption of fuel during initial establishment, management and harvesting of Rhode grass are higher. Table 20 shows that 71% (422.02 KgCO2) of Emission produced at 1st season of forage production; see a breakdown in Appendix 6.

Table 20: summary of Fuel used and emission

Component	**1st Season Of Establishment**	**2nd Season After Establishment**	**Total/Year/Ha**
Fuel	158.8	64.22	222.34
KgCO_2	422.07	171.47	593.54
Energy Consumption (Mega Joules)	5675.07	2317.85	7992.92
%	71%	29%	100%

4.9.2 GHG emission along the chain

The quantification of energy consumption and GHG emissions were based on data of Rhode grass bales purchased by Githunguri Dairy cooperative society procurement department over a period of one year as from June 2018 to May 2019. According to GDCS procurement, 27,199 bales of Rhode grass received from five different farms in Narok county, Nakuru county and Nanyuki. GHG emission and energy consumption was estimated based on; trucks capacity, the distance -round trip, and the fuel consumed.

In Olenguruone Dairy cooperative Society, there were no records related to forage supply, therefore, no emission was quantified in line with Society.

Table 21: GHG emission and energy consumption along the chain

					Energy And CO2e Along The Chain (Production To Consumption)			
SOURCE OF FORAGE	Type of forage	distance (km)	litre of diesel	cost of fuel	energy consumed/ trip	KgCO2e emission	MJ/bale	KgCO2e/bale
Eor-Ekule	Rhode grass	280	93	9800.0	3350.7	249.2	6.701	0.4984
Ngorengore	Rhode grass	372	124	13020.0	4451.6	331.08	8.903	0.66216
Ngongongeri Farm Njoro	Rhode grass	340	113	11900.0	4068.7	302.6	8.137	0.6052
Delmonte Cannaries	Pineapple waste	110	37	3850.0	1316.3	97.9	2.633	0.1958
Ruaraka-Nairobi	breweries waste	66	22	2310.0	789.8	58.74	1.580	0.11748
Kenfine Farm Junction To Kwa Maiko	Rhode grass	11	4	385.0	131.6	9.79	0.263	0.01958
Nanyuki	wheat straws	396	132	13860.0	4738.8	352.44	9.478	0.70488
Mwea Irrigation Scheme	Rice straws	216	72	7560.0	2584.8	192.24	5.170	0.38448

key

- fuel consumption at an average of 3 litres of diesel per kilometre
- 500 bales per trip (10-tonne truck) -
- CO2e emitted per unit Kilometre per bale =0.00178 kg CO_2 (KgCO2 per bale/Distance=0.4984KgCO2e/280km 0.00178)
- energy equivalent consumed per unit Kilometre per bale=0.2393Mj
- Emission and energy factors for diesel fuel 2.67 and 35.9 respectively

Combination of energy consumption and CO_2e at production and along the chain

As shown in table 14 and table 12, table 13 gives the summary of energy consumption and GHG emission at the production level and through the chain. The assumption was made on the average distance of 200km at 0.00178 kgCO2e and 0.2393Mj per Km per Rhode grass bale.

Table 22: summary of GHG emission and energy consumption per bale

	At Production Level	The Forage Value Chain	Total
$KgCO_2e$ Per Bale	0.8544	0.356	1.2104
Energy Consumption (MJ)	11.488	47.86	59.348

4.9.3 Emissions from synthetic fertilizers

According to the interviews from key informants and forage producers, the yield of forage per hectare has declined by above 25%. As from 700 to 500 hay bales per hectare per season. Majority of forage producers are now applying synthetic fertiliser at the rate of 250Kg/ha/season to improve their production. As per respondents, majority of farmers apply NPK 17%N during planting, while UREA and CAN are used for topdressing. It was also confirmed that small scale farmers are applying manure fertiliser from cows. Using different formulas of Tier 1 IPCC (2006), CO_2 and N20 was calculated from Urea fertiliser, CAN (26%N) and NPK (17%) as shown in the calculation below.

Quantification of CO2 emission from area application
CO_2-C emission=M*EF…………………………………………………………(IPCC 2006)
Where:

M= annual amount of urea fertiliser tonnes/year
EF= Emission factor, tonnes/year
I Year=2 seasons
CO_2= CO_2 emission $*^{44}/_{12}$
CO_2-C emission= $2*^{250kg}/_{1000}*20\%$
CO_2-C emission=0.1 tonnes/year
CO_2 =0.367tonnes/year/ha

Quantification of CAN and NPK fertiliser per hectare
Nitrogen emission from synthetic fertiliser applied was calculated using the formula below.
N2O (direct) = (FSN + FON + FCR) × EFN × 44/28 (kg N2O/ha),
Where:

FSN = Amount of synthetic fertilizer applied (kg N/ha)
FON = Amount of annual manure applied (kg N/ha) if included
FCR = Amount of N crop residues above ground and below-ground (kg N/ha)
EFN = IPCC emission factor for added nitrogen (0.01 kg N2O-N/kg N)

Calculation of N from CAN (26%N) applied

Where:
0.0075 N2O-N/Kg N =is the emission factor N_20 from the amount of leached N as per IPCC (2006).
0.015 and 0.012 are the amount of N above and below the ground respectively as shown in Annex 2
Therefore:

N2O= (500*26%)+0+0.015+0.012)*0.0075*44/28

N2O=(130+0.027)*0.011786
130.027*0.011786
= 1.532Kg/ha/yr
CO_{2e}=1.532*298

= 456.7
= 0.739 KgCO2e/bale **(***Refer to table 13***)**

Calculation of N2O from NPK (17%N)

N2O= (500*17%)+0+0.015+0.012)*0.0075*44/28

N2O= (85+0.027)*0.011786

= 85.027*0.011786

= 1.0Kg/ha/season

CO_{2e}=1*298

= 298kg

= 298Kg/494 bales (*refer to table 13*)

= 0.603kgCO2e per bale

Estimation of GHG emission in Githunguri.

Estimated GHG emission of manure

Finding from interviews and observations, the majority of farmers in Githunguri do not have a place to dispose of waste from their dairy cows. According to GDFCS, records show that 24,936 members registered. Given the average of 2 dairy cows per member, the total animals are estimated to be 41, 385 dairy cows as per County Government Livestock department record 2018 (see annexe 8).

However, according to Font-Palma, (2019), the dairy animal produces 8% of its live weight as manure and 20% of manure is dry matter. Using the findings of Aguirre and Larson (2017) 1 tonne of manure produces 33,579g CO2e table (see annex 7). The total GHG emitted by Githunguri DFCS members is equivalent to 1 ton CO_2-e/day (See Annex 4).

Also equivalent to the loss of nutrient per day as illustrated in table 235.1Kg of Phosphorous, 1,145 Kg of Potassium and 148.99 Kg of Nitrogen.

Table 23: nutrient produce per kilogram of manure

Nutrient	g/Kg	Total dry manure produced by Githunguri dairy farmers Kg per day	Total kg of nutrients/day	Kg lost per year
P	0.789	297,972	235.1	85,811.5
K	3.845	297,972	1,145	417,925
N	0.5	297,972	148.99	54,381.35

Source: Bernal, Alburquerque and Moral, (2009)

4.10 Climate-smart practice

Climate-smart practices were classify based on observation and interviews on actual activities practice by forage producers and dairy farmers. Also the awareness of the practices.

Dairy Cooperative was classified based on the awareness and knowledge disseminating to the farmers as service providers concerning climate-smart agricultural practices.

Table 24: climate-smart practices

	Climate-smart agricultural practices					
Sector / **Agricultural Practices**	**Dairy cooperative**		**Dairy Farmer**		**Forage producer**	
	Yes	No	Yes	No	Yes	No
Efficient energy use		✓	✓			✓
Rainwater harvesting	✓		✓			✓
Improve manure management		✓		✓		✓
Conservation of agriculture	✓		✓		✓	
Disaster risk management		✓		✓		✓
Reduce post-harvesting losses		✓	✓	✓		✓
Breeding of new crops/fodder	✓		✓			✓
Afforestation and reforestation		✓		✓		✓
Improve land use management	✓		✓			✓
Restore degraded land and organic soil		✓	✓			✓

CHAPTER 5: DISCUSSION

5.1 Introduction

The dairy sector in Kenya is experiencing strong growth in milk demand, which offer great opportunities that lead to new investments as well as the value chain development. To farmers, increasing productivity linked to the effective delivery of inputs and service. Marketing opportunities for farmers rely on lowering milk production cost and improving quality in order to access milk-processing capacity. Milk production and quality are directly proportional to the feeds given to the animals.

However, based on the observation results, dairy farmers in Githunguri and Olenguruone are facing feed challenge as a result of climate change. According to IPCC 2011, climate change is a persistence anthropogenic changes in the composition of the atmosphere or in land used caused by natural processes or external forcing's.

Results of observation and interviews made during the case study, state that besides climate change and animal feeds, land size is one of the key factors affecting the dairy farmers, forcing them to outsource dairy feeds and forages from other areas. Due to limited land sizes, the cost of feeds accounts up to 60%-70% of the total cost as highlighted by Wambugu (2011). Through observations, it was noted that farmers are using a variety of forage like Rhode grass hay *(Chloris gayana),* wheat straws, rice straws, Kikuyu grass, maize silage, maize stovers and by-products such as pineapple and breweries waste.

In Olenguruone, it was noted during the interviews and observation that, majority of farmers have larger land sizes like four to ten acres compare with Githunguri which have a quarter of an acre. Farmers are keeping their dairy animals extensively under paddocking. They grow varieties of fodder tree such as Calliandra, Sesbania and Leucaena and other fodder such as Sweet potato vines, maize silage, maize stovers, Rhodes grass, Nandi Setaria, Columbus grass, Kikuyu grass and oats. During a dry spell, farmers buy Rhode grass hay mixed with desmodium or plain Rhode grass. Due to prolong droughts for the past few years and the pieces of training from SNV, farmers are now adopting forage preservation methods. According to the respondent, few farmers are now buying fodder from their fellow farmer during rainy season and store to feed their animals during the dry period. The respondent concluded that only a few, especially lead farmers to have stores but not enough to keep the forage for all year.

5.2 Forage supply chain in the Githunguri and Olenguruone dairies

From this study's findings, the forage supply chain was found to be similar to chain illustrated by USAID-KCMS (2018), however, observation shows that the forage chain varies depending on the type of forage. In Githunguri, the finding shows that there is a short-chain for Napier grass, roadside grass and by-products for pineapple and breweries, medium and long-chain covers Rhode grass hay, wheat straws, rice straws and by-products of pineapple and breweries. The shorter the chain the few the actors and the longer the chain the more the actors or player. This observation is in line with USAID-KCDMS assessment report 2018, indicated that Napier grass has the shortest value chain as the farmer buy or sell directly to the consumer (other dairy farmers). This was also observed during the case study in Olenguruone. The medium value chain was observed in Githunguri Dairy Farmer Cooperative Society (GDFCS), where the cooperative the take the responsibility of buying forage on behave of its members.

For the shortest chain, farmers or chain actors tend to build a mutual relationship; they are easy to make agreement through written paper or word of mouth. The research shows that this short-chain was much practice in Olenguruone than in Githunguri region. Medium-chain shows to be much reliable and sustainable especially in Githunguri Dairy Farmers Cooperative Society. Through stores department, forage producers are called to apply for tender to supply the forage (Rhode grass hay). Then the committee body is formed to assess the application, whoever wins for tender, his/her farm will be assessed to find out the quality in hay on the farm. In terms of chain governance, the research identified one type of forage value chain governance in Githunguri DFCS, that is market type. The findings through interviews shows, there no formalisation in cooperation between the producer and the cooperative and the cooperative to a dairy farmer, the cost of switching to a new partner is low for both. It was found that the cooperative has no controlling interest in the production; it is only giving the kind of standards they require. They hardly provide the information on what their members want and how to produce it. This has caused mistrust from other members forcing them to shift the sourcing.

Long-chain was found to be common in both areas of research; farmers buy forage from local stockists who are buying from other traders. The chain is named long due to several players along the chain. Some of the farmers in Githunguri prefer this chain because of varieties of hay in the market. '' I prefer buying from agro-vet because I can bargain the price, secondly because of competition, agro vets bring high-quality hay and finally I may get a variety of hay-like wheat straw, rice straws, breweries waste, in which our cooperative is not selling,'' one of the respondents during interviews. The findings show that, in this kind of chain, farmers are not able to trace back the source and due to distrust, there is no transparency. It was noticed that there is no adequate communication between the parties thus raising the chain cost.

Climate change has led to forage scarcity causing high demand as reported by Girdhar k. and Samireddypalle A (2015), that the most visible effect of climate change is the production of forage crops which have declined in yield. Findings from keys informants and focus group discussion, cooperatives in collaboration with Government institution such as KALRO, MoALF and NGOs like SNV are training farmers on forage production, preservation and feeding techniques as mitigation strategies. However, farmers have not adopted those strategies, as they do not have storage facilities. The demand for forage is higher during the dry season and lower during rainy seasons. During the wet season, farmers have enough natural forage, the prices of hay bales are lower and of high quality. The demand for hay, therefore, is low. Farmers do not buy due to lack of storage facilities and knowledge of demand and supply. Some traders buy during this period at low prices and sell when the prices are high. This result in price fluctuations.

Knowledge of forage production is underdeveloped, government and other chain supporters have less consideration in the sector. Forage production is not yet recognised by financial institutions as a cash crop. Many farmers are not able to venture into the business due to the high initial cost.

5.3 Chain governance

Githunguri and Olenguruone Dairy Farmers Cooperative societies are smallholder farmer-owned dairy cooperatives. Their core businesses milk collection, cooling, processing and selling. Olenguruone DGSF collects milk, cool and delivers to NKCC and Happy cow processor. Due to the constraint of milk fluctuations, the cooperative has diversified its core values by providing agricultural inputs and services to its members. Extension of goods provision is stretching day in day out due to different factors affecting farmers.

Besides the normal farm inputs, Githunguri Dairy Farmers Cooperative serve their members in a unique way. They provide food-stuff for people at the same time feed and forage for their animals and the members pay through the check-off system. It was noted that the enterprises deal with cooperative and the dairy farmer or cooperative and forage producer was in 'arm's length' transactions. When the farmer has less than the required amount of milk in his account, he/she was not allowed to take well in credit. According to Humphrey, J. and Schmitz*, H., 2001 described this kind of governance as market-based type.

5.3 Cost of production

There are various fodder types grown in researched areas, but the most common and widespread are Napier grass and natural pasture. Rhode grass hay is the commonly traded while the Napier grass dominates the short-chain, mostly between the dairy farmers within proximity. According to SNV (2013), they consider fodder to be the backbone of the industry, largely because dairy cows are ruminants, making them highly dependent on forage for milk production.

Majority of small scale farmers are producing Rhode grass for subsistence and sometimes sell excess during the dry season. Medium and large-scale farmers are growing for commercial purposes. Though the number of producers is increasing, the demand for forage is also increasing at a high rate and climate change has an impact on production. According to farmers, the cost of production is increasing annual compared to previous years where a farmer was getting more than 50% gross margin at first season and over 150% in the second season after establishment. This was in line with KCDMS survey report 2018. High-interest rates from financial institutions, taxes for farm inputs especially machinery, inflation and lack of access to credit facilities have contributed to the high cost of production. From the finding of this study through the interviews conducted, farms were categorised based on the resource specifically machinery. The medium-scale producers found to be contracting service related to forage production. This is due to the high cost of farm machinery and limited access to finance. Comparing and consolidating two medium farms from different regions (Kiambu and Narok), which do not have all farm machinery, shows that there is low gross margin (2.15%) per hectare at the initial stage of Rhode grass production based on primary data and interviews. This was caused by the high cost of establishment. Same two farms recorded 52.1% gross margin per hectare in the second season of harvesting. Since most forage like Rhode grass, which is established once after 5-7 years, there is no other cost besides the management and harvesting cost. Large farms with machinery recorded higher than the medium farm with 19% gross margin per hectare but closely the same for the second season. According to the farmers, increase use of synthetic fertiliser has change soil PH thus leading to infertility. For the last 3 years, the yield per hectare has reduced by at least 25%. This concurred with Kazafy and Sabry, (2015), who state that plants that grow in overly fertilised soil are deficient in a micronutrient, thus lead to reduction of yield per unit area. They further stated that fertilizers lead to soil degradation, finally less income from the production. Based on climate-smart agricultural practices, farmers are clearing trees to have space for forage production. Mnene 2006 and Kibet et al 2006 revealed that, despite the availability of various knowledge channels, farmers lack information access on agricultural practices.

5.4 Manure management

During the interviews with transporters in Githunguri, it was found that not only hay bales were their main business but also manure. The respondent illustrated, they carry the forage to Githunguri and go through Kajiado County more than 100 Km away from the consumer in Githunguri and producer. Based on the findings, Githunguri Dairy cooperative has 24,936 registered farmers with an average of 2 cows all can produce up to 29.8 tonnes of dry manure per day. According to Bernal, Alburquerque and Moral, (2009) report, 1kg of manure produce 0.789g of phosphorous, 3.845g of potassium and 0.5 g of nitrogen. Therefore, 297,972kg of manure can produce 148.99 Kg of nitrogen (297,972*0.5g/1000), equivalent to 54,381Kg of Nitrogen per year. With the average of 64.22 kg nitrogen per hectare (application rate per hectare as per respondent -250kg of CAN of (26%N)/ha). Manure from Githunguri members can be used in 847 hectares of land per year. Farmers should dry their manure and sell to forage produces for additional revenues.

5.5 GHG emissions

GHG emission from land-use consist largely of CO_2, N_2O and CH_4 generated mainly from forage management activities. All emission may be expressed for convenience and easy comparison across domains in Gigagrams of CO_2-equivalents. The main activities consist of land preparation (diesel fuel), planting (fuel and fertiliser), forage management and harvesting. Transportation is one of the main sources of GHG emission, as illustrated by Liu, Cet al (2016), the major contributors in crop production, include the emission associated with off-farm transportation and delivery of input products to the farm-gate, however, according to K Lunden Pettersson 2016, stated that transportation has not large impact on environment if logistic is effective.

According to the research findings, there are higher emissions from fuel during farm establishment, which contribute up to 593.53 KgCO2 equivalents/ hectare/ year and energy consumption of 7,992.92 MJ/year. This was due to heavy uses of farm machinery during ploughing, harrowing, planting and harvesting.

The demand for forage has increased the prices per bale and the cost of transportation is also very high, making it difficult for farmers to buy in bulk enough for all year. Lack of storage facilities is one of the factors contributing to high emission along the chain, as farmers tend to make several trips for the same products. Using the data from Githunguri cooperative society, it shows that, using a truck carrying 500 bales from the same farm of 100 Km, then emission will be 178KgCO2 e. while using large truck emission will be lower. The findings show that the longer the distance covered and the more the trips the more the GHG emission.

	At Production Level	Fertilizer inclusive	The Forage Value Chain	Total
$KgCO_2e$ Per Bale	0.8544	1.34	0.356	2.55

5.6 Scalable climate-smart practices in forage supply chain

Development of a high-quality, innovative forage sub-sector will minimize farmers' production costs and seasonal fluctuations in milk supply, as well as improve living standards.

Manure management- based on the findings, lack knowledge on manure management has led to high GHG emissions, loss of possible revenues and conflict creation with authority (National Environmental Management Authority).

Energy consumption- Energy is very important in every stage of food production transport being part of it. Using improve means of transport in terms of size and efficiency will reduce energy loss, at the same time GHG emission. Based on the research finding, consumption was high.

Land degradation- with the assistance of private sectors, Non-Governmental Organisations (NGOs) and government, creating awareness and training will improve land fertility. This will lead to the sustainability of forage and dairy sector.

Post harvesting loses- lack of storage facilities have contributed to low adoption of climate-smart practices. Covering hay in the hay in the field is exposing to high risks such as bad weather and a high percentage of waste which might forage causing scarcity at the end. Lack of storage facilities at dairy farm level also contributes to the high loss of forage as the farmer is forced to feed the animal more than the required.

5.7 Limitations

Due to small sizes between the chain actors, the researcher might have missed crucial information, which needs to address.

Reliable data: some farms were lacking proper records which made difficult for the researcher to find sufficient information to support his research. During interviews with respondents, most were not keeping day-to-day operational records and they were not able to account for their cost. The researcher was forced to use related items to estimate the cost of the actual item. Due to different locations, within the same area or in different areas the variation of the same data was high.

Lack of prior studies: forage value chain is an underdeveloped business in Kenya. Due to climate change, new areas are experiencing forage scarcity. Because of this, no research has been carried out in the same areas.

Confidentiality: Some questions like the employers' salary were making the respondent unconfident even after the research assure them of confidential.

Accessibility: Poor roads in some areas were difficult for the research to get into the destination on time, use of motorbikes as means of transport was not very health which was causing frequent fever to the research.

Some firms were very restricted to strangers, the research tends to act as if he was a farmer to be allowed to enter and meet the managers.

5.8 Role as a Researcher

Introduction

This research was carried out in Githunguri and Olenguruone Dairy Farmers Cooperative Societies. The field research took a period of two and a half months as from 1st June to 20th August 2019.

My main objective of carrying out this research to do an in-depth analysis of forage value chain in Githunguri and Olenduruone Dairy Farmers Societies by identifying the chain actors and supporters. Also to estimate the cost of production and quantify GHG emission along the chain and at the production level in order to develop a business model for scaling up climate-smart dairy farming practices for both Dairy Farmers Cooperatives. This research was a continuation of Shumba's 2018 who carried out research on scaling up dairy feed production in Githunguri. The research is under NWO (Netherlands Organization for Scientific Research), a Dutch organization that aims to ensure quality and innovation in science and facilitates its impact on society. NWO works in collaboration with the 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. Based on his findings scaling up dairy feed was a challenge due to small sizes of land in Githunguri. Dairy farmers are not able to produce their own forage but purchasing from other regions away from Githunguri. We were three researchers working on the same project but different topics.

As a new researcher, I formulated my own objective that focuses on forage. The objective helped me to generate questions; the main questions and sub-questions. I carried out desk research to collect relevant concept theories of related field and information for a better understanding of the research context. Also to use during discussion and triangulation of my research outcome. I made a presentation in which I was guaranteed to proceed. During this time, we were making phone calls organising the first meetings with the management official of the cooperative. Initially, we were communicating with the officials of Githunguri Dairy Farmers cooperative.

Field study

At first, it was difficult for me to imagine how I will start my project, I had mixed feelings because the area of research was new to me. Secondly, I did not know the kind of people I am going to meet. Immediately we reached our country, we organised our first meeting with Githunguri cooperative officials, which was scheduled to be the following week.

During our meeting, we introduced ourselves and brief them on what we are doing and why we choose to do it there. Besides asking the basic questions on how we are going to conduct our field research, they were much interested to know the benefit of our research to their organisation. Later, we were assigned extension officers to help us in the fieldwork. On the first few days, my work was easier; the extension officers were there to help us, especially acting as interpreters, also introducing us to the farmers.

My main aim to be with the farmer was to interview and observe what he or she has in terms of forage, storage facilities and other resource-related with forage. Meeting with the first dairy farmers help me to readjust my questions and to classify the forage chain map. I classify the forage chain into three types (short, medium and long-chain) depending on the number of actors or players.

Since my objective was mapping up the forage supply chain, I moved away from the farmers' circuit to find out other chain players. This was through snowball techniques. Business people were on the second level after farmers. This was not easy; getting information from a businessperson was like cooking stones. Later I mastered techniques of interviewing them. The technique helps me along the way.

At first, I made my plan based on the chain type. I start focusing on short chains, followed by a long chain. In short chain, farmers are acquiring their forage directly from producer or manufacturer (breweries waste and pineapple waste). In Githunguri, farmers were feeding their dairy animal with breweries waste from beer processing company and pineapple waste from Juice company.

I visited those factories as well as the forage producers who were a closer part of the short-chain. It was also difficult to access the factories but it forced me to act as a farmer who is interested in the by-product and want to buy in large quantity. Using the same tricks, I was given an opportunity to meet their production managers, which helped me to acquire the information I was searching for.

Short-chain was easier, I found the long chain to be more complicated. Many respondents were not ready to spend time with you or even to respond and also they were not ready to give any information. I later learned that because of stiff competition in the field, some trader was thinking that I was spying. Also being a stranger and not speaking in the same language with them made everything more difficult. However being aggressive and curious to know their interest, I then worked with less effort, I became one of them. While I was going through the long-chain, I managed also to interview some key informants and make appointments with others. Medium-chain was easier because the Dairy Cooperative was involved in the chain and they gave me a different producer. Later I compare the three chains a choose one in long and short-chain and two from the medium.

Through the help of the Dairy Cooperative and some key informants, I was allowed to access those farms without any challenge. I was very lucky to find most of the producers harvesting and selling their hay. I was allowed to go through their record and also their farms see pictures in Annex 4.

When I was through with Githunguri forage supply chain, my colleagues also were through with their fieldwork. We organised and travelled together to Olenguruone dairy Cooperative whereby we organised a meeting with the dairy officials, introduced ourselves and also our aim of going there.

Olenguruone had only two types of chains, short-chain and long-chain. The short-chain was involving farmers to farmers or farmer to forage to transporters to producers. Long-chain, on the other hand, was involving farmers, retailers (Agro-vets), transporters, brokers and producers.

I started the same procedure but more intelligently. I made a good plan on how to carry out fieldwork at the same time organising the interview with the key informants. For the fieldwork, the chains were not more complicated as compared to that of Githunguri.

When we were through with the fieldwork and interviews with some key informants, we requested the cooperatives to Organise for us Focus Group Discussion. Meaning of FDG was to confirm and triangulated the finding, especially at the consumers level. Since they were the members of the Cooperatives, then they understand well its operation. Through triangulation, FDG helped me to develop the chain governances and the business model.

Challenges and personal development

I was overcharged several times because of my ignorance. In Kenya, before you are carried by a motorbike or any public means, you must inquire the fare and the place. Some realised that I was stranger and charge me twice or thrice the normal price.

It was also very challenging for going to unknown- many places were far, sometimes requires a day travelling. This was due to poor road passage and weather conditions. In most cases, I was using a motorbike to travel to rural areas, sometimes long distance in a rough road. Another issue was the conflict of appointments. It was not once but twice when I made an appointment with key informants, and their response was colliding.

Concerning data analysis, I learned that compilation and analysing qualitative data is very complicated and time-consuming especially when you mix up the raw materials. Sometimes it was much difficult to transcribe the data when I was in the field because of tiredness due to travelling. I have no issue analysing quantitative data. Compiling and making the relevant layout design of the final document was also a challenge for me.

Throughout my field research, I learnt that every single data is very important in research, sometimes research may assume some information but to analyse the data due to the missing link. Good communication skill is another important factor in research, for accurate and reliable data, one must know how to communicate well with the respondent not only through oral communication but also through glistening and gestures. I remember when I was interviewing one of the managers in a farm concerning cost and revenues because I was concern about the total cost including the wages and salaries, I learned that he was not confident enough because of few other workers around.

As a researcher, you have to be flexible while you are in the field and committed you to have to send yourself and to be somebody else under your own supervision.

Conclusion

For this research, it was very helpful to me not only for academic purpose but also to my organisation. To be in the field, I realised a big loophole in which I and my organisation have to work on.

The forage value chain is still far in terms of research especially on Greenhouse Gas emission, I recommend more research is needed to be done.

Dairy cooperatives should take forage as a key sector to be supported, this will help to sustain its core business of milk processing.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The main objective of this research was to carry out an in-depth analysis into the forage value chain with the objective of developing a business model for scaling up climate-smart dairy farming practices in Githunguri and Olenguruone Dairy Farmers Cooperatives. This chapter, therefore, provides a summary of the finding from the research to address the objective by answering the main questions and sub-question

Existing relationships among forage chain actors

From the findings, the forage value chain in both Dairy cooperatives have similarities in terms of a relationship. The business depends on arm-length of the other actor. Based on the interview with chain actors, the forage on the market depends on the demand. Prices vary according to the type of forage and demand. No control over the supply or the prices.

The cost of forage production

Comparing two kinds of farms, it was observed that, farms with machinery and equipment have high Gross margin at the initial stage of production (19.2%), the cost of production is low as KShs 11.8 per kilo of Rhode grass hay. While the farm without farm machinery, that is contracting the service, have a low Gross margin at the initial stage of forage establishment (2.15%) and the cost of production is high KShs 14.35 per kilo of Rhode grass. Rhode grass is perennial grass, once established, the crop with good management can be harvested more than seven years but poor management will less than four years. Management includes weed control and soil maintenance.

The level of demand and supply for forage in Githunguri and Olenguruone

It was observed that due to the high demand for dairy by-product has increased the demand for the forage. It was assumed that, only dairy farmers who are keeping their animals under intensive dairy farming system purchase forage. Surprisingly, in Kenya, Maasai community who have been known to be pastoralists and moving their animals freely in a communal land are now purchasing forage for their animals. In Githunguri, forage shows to have more demand and slightly low in Olenguruone but the trend is growing due to climate change. According to forage producers' view, demand is high and are never satisfy the market

The capacity of forage producers and key suppliers to meet demand

Based on Githunguri Dairy Cooperative store department records, only *27,199* bales were purchased during a period of twelve months; July 2018-June 2019. This is contrary low compared to the total estimated number of animals per member. According to Githunguri sub-county records 2018, the total animals within the region were *41,385* with an average of two dairy cows per member. Therefore, the total number needed for the whole year 15,105, 525 bales which are 555 times more than the purchase of the Dairy Cooperative. The capacity for the producers to satisfy the demand is quite far away as they produce an average of 200,000 bales per year (see table 18).

The status of GHG emission and energy consumption along the forage supply chain

It was noted that emission produces due to forage production is slightly low compared to other annual crops Annex but high at the initial stage.

The scalable climate-smart practices in fodder production and its suppliers

For efficiency and sustainability of forage production and supply in Githunguri and Olenguruone, it was observed that, for scaling up the supply chain, the following factors must be considered; construction of storage facilities, manure management, land used management, forestation, post-harvesting losses and efficient use of energy.

Climate-smart technologies

During the fieldwork, it was noted that the majority of chain actors are using old machinery with fewer efficiencies in energy consumption. It was evident that despite the available information and widespread researches of climate-smart technologies, the majority have not adopted the climate-smart technologies in the forage value chain.

Possible business models

Figure 16 and 17 shows the current business model from the two Dairy Cooperatives, Githunguri and Olenguruone Cooperatives. They are very clear that their core value is based on economics and not environmental and social factors. For the sustainability of the sector, the possible business model canvas should be inclusive, that is economic, environmental and socially inclusive.

Chain governance to scale up climate-smart fodder supply

The findings of the research show that the Dairy Cooperative has powers to control and maintain the sustainability of the forage for their members. However, based on the findings, Dairy Cooperatives are practising Market-based type governance. For scalability, the cooperative should change the type of governance from market-based type to relational type. According to Gereffi et al 2005, in relational type, there is interactions between buyers and sellers are characterised by the transfer of information and embedded services based on mutual reliance regulated. In that aspect, a lead firm that is the Dairy Cooperatives specifies what they need, and controls the highest valued activity in the chain, thus having the ability to exert more control over the supplier.

Factors influence the possibilities for scaling up the forage production and supply practices

Economic factors- high-interest rate limit the potential of forage producer to expand their business thus affecting the possibility of scaling up. It also noted that many have an interest in the business but the financial institution consider to be high risk thus increasing the interest rates making it difficult for a new person to adventure into the business.

Taxes –high rate of taxes also influence the forage production and supply. Taxes imposed on farm input are high.

Demand and supply- based on the findings there is an imbalance in terms of demand and supply. High demand low supply especially in Githunguri region.

Environmental factors- according to the findings, climate change is the main challenge for scaling up. This has led to low production due to unreliable rainfall thus increasing demand. Pollution due to high use of synthetic fertiliser and fossil fuel may influence the possibilities of scaling up.

Social factors- This was seen in terms of stakeholders and chain actors. This is also in line with Porter, M.E. and Kramer, M.R., (2006). It was noted that there is a weak relationship between the chain actors. The dairy cooperatives have less consideration on the relationship with other stakeholders in terms of forage production and supply.

6.2 Recommendations

Dairy Cooperative Societies

Capacity building: Cooperatives should initiate capacity-building processes by developing partnership collective work programmes with other stakeholders to establish more effective climate-smart practices and the development of strategies.

Governance: enforcement of policies action and improvement on the governance of forage chain systems

Communication: develop and implement best communication strategies for climate change mitigation to forage producers and other stakeholders through training and extension services.

Other mitigation strategies: cooperative and other supplier need to use large trucks to avoid more emission and reduce the transport cost, which will lead to the sustainability of dairy.

Partnership: create a long-term partnership with government institutions like KALRO, ILRI Agricultural Development Corporation (ADC) and learning institutions e.g. Egerton University that have large parcels of land that are not utilised for forage production.

Dairy farmers

Storage facilities: farmers should construct stores to keep enough forage that lasts for a year or during draught season.

Manure management: dairy farmers in Githunguri dispose of their manure along the road, which causes emission, and other environmental effects, while forage producers experience manure scarcity for their land reclamation. Farmers will generate revenue from manure by drying and selling to forage producers.

Forage quality: farmers shall consider the quality of forage more than quality.

Supporters

Research institutions: should improve on information infrastructure to ease the dissemination of technologies and innovations in the forage value chain

Government policies: government bodies through the department of livestock should support the climate-smart practice by implementing new strategies and policies that favour forage production.

Forage producer

Soil fertility: should use manure for fodder production and reduce deforestation.

Storage facilities: should have well-maintained stores for forage conservation and avoiding waste.

Land preparations: use of heavy agricultural machines during land preparation has increase energy consumption and GHG emission, medium-scale producers should be encouraged to use contracted service to reduce emission and also the cost of maintenance since the Rhode grass is perennial crop which is renewed after 5-7 years, the farmer should be optimised the profit.

6.3 Proposed Business model

Table 25: Proposed Business model for Rhode grass.

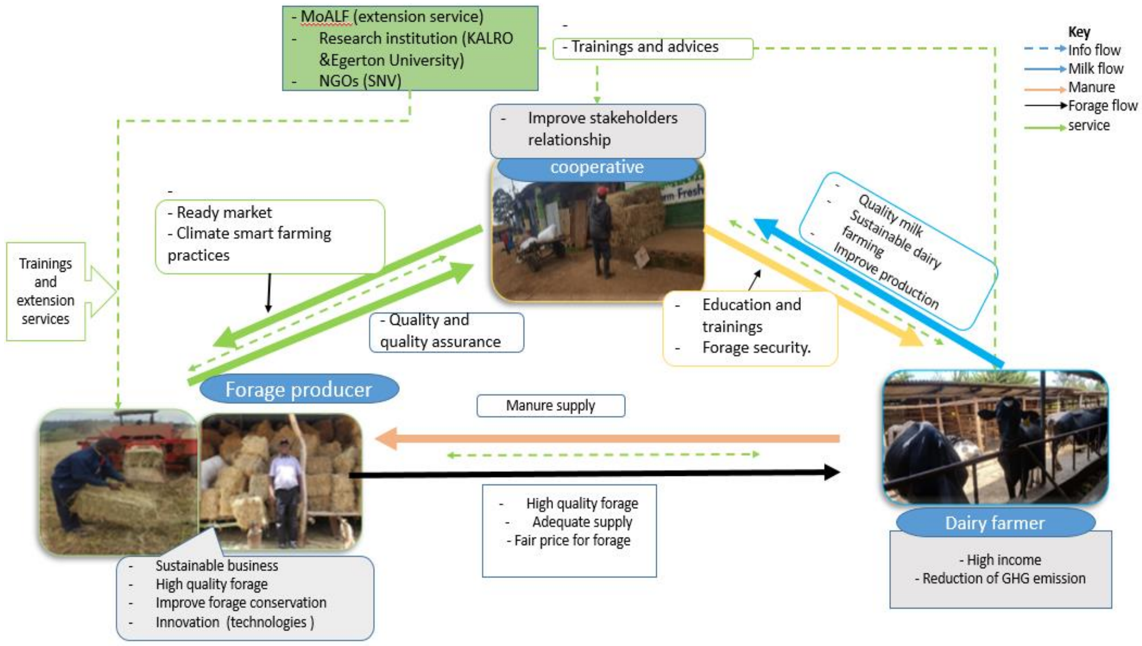
<table>
<tr>
<td rowspan="2"><u>Partners</u>
County livestock department
Research Institutions (KALRO and ILRI).
Learning institution: Universities and Middle Colleges (VHL and Egerton universities)
Forage producer
Smallholder Dairy Commercialisation Projects
KBS- for quality assurance</td>
<td><u>Key activities</u>
Education and training to Chain actors.
Demonstration of climate-smart practices and new technologies through Lead farmers (forage producers and dairy farmers).

Linking farmers to other experts</td>
<td rowspan="2" colspan="2"><u>Value proposition</u>
-Reduction of carbon footprint.
-Provide CSA technologies that increase the yield of Rhode grass.
-
-Provide quality fodder and forage production and supply
Knowledge transfer</td>
<td><u>Customer relationships</u>
Loyalty
commitment</td>
<td rowspan="2"><u>Customer segments</u>
Dairy farmers
Intensive, semi-intensive and free-range dairy farmers</td>
</tr>
<tr>
<td>Key resource
Human resource
Dairy farmers
SACCOs</td>
<td>Channels
Lead farmers (field experimental)
Farmers training
Exhibitions
Personal contacts
Field days
Extension service
TVs, Radios and mobile application</td>
</tr>
<tr>
<td colspan="3"><u>Cost structure</u>
Project facilitation - Labour cost
Staff Salary - Seedling</td>
<td colspan="3"><u>Revenue stream</u>
Sales of Rhode grass hay</td>
</tr>
<tr>
<td colspan="3">The social and environmental cost
GHG emission through forage production and transportation.
Cost of exhibitions and fieldwork</td>
<td colspan="3">Social and environmental impacts
Climate-smart mitigation practice
Awareness creation
Improve soil fertility
Reduction of GHG emissions</td>
</tr>
</table>

Importance of a newly developed business model

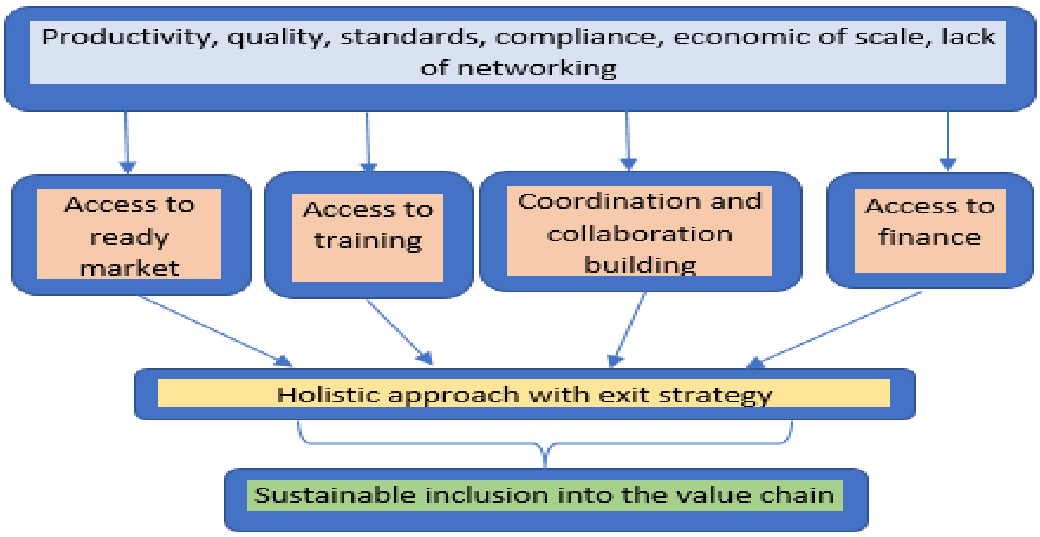
1. Coordination and collaborations- According to Gereffi, Fernandez-Stark, Bamber et al 2011, coordination and collaboration amongst the stakeholders are crucial for chain performance and upgrading. This will improve the opportunities for the cooperatives and the sustainability of the dairy industry.
2. Efficiency: involvement of different stakeholder will help in the reduction of GHG emission as each as a role.
3. Cost reduction: through more sustainable production processes with low energy consumption and less post-harvesting losses.

Figure 19: summary of sustainable Business model



Source: Author

Figure 20: Summary of Model for sustainability



Source: Fernandez-Stark, et al. 2012.

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ANNEXES

1. Unstructured questionnaires and checklists

1.1 Intensive dairy farmer (forage consumer)

1. Type of forage used by the farmer
    a. Rhodes hay
    b. Wheat straw
    c. Natural grass hay
    d. Napier grass (planted or leased)
    e. Crop residues
        i. Pineapple waste
        ii. Breweries waste

Reasons for using one or more of the above forage

The cost of the above forage

2) The source of forage
    a. private retailers (agro-vets)
    b. cooperatives outlets (dairies)
    c. Direct from producers
    d. Farmers producing its own forage
3) Kind of relationship with the supplier
    a. Business to customer relationship
    b. Business to business relationship

4) The buying price of forage
    a. Reasons for buying at the above prices
    b. Stability of prices of forage
    c. The total cost per unit
5) Means of transportation from the source to the farm
    - Trucks
    - Motorbikes
    - Donkeys
    - Other means

    a. The total cost of transportations
    b. Other related costs
    c. Distance from the source to the farm
6) Farmer's suggestion in relation to
    a. Cost related to forage supply
    b. Forage supply chain governance

Observation

1) Type of forage
2) The storage facilities
3) Quality based on physical appearance
4) Type of transportation

1.2 Retailer

No.	question	Type of forage	
	1.	i. Rhode grass bales	
		ii. Wheat straw bales	
		iii. Natural grass bales iv. Desmodium v. Ricestraws vi. lucerne	
	2 Where do you buy the forage?		
	3 What value do you add and technology use		
	4 How much do you buying and selling?		
	5 Do you have any relationship with your forage suppliers?		
	6 What about your customers (Business to business or business to customer relation)		
	7 Who are the key suppliers		
	8 8 What do customers want while buying, is its size, quality or weight?		
	9 Do prices go with quality?		
	10 How frequently do you get from your supplier		
	11 What are the factors influencing the forage business and supply?		
	12 What is the capacity of your forage store		
	13 Are you aware of climate change?		
	14 What are the means of transport from the supplier and to your customers?		
	15 How far do you get your product from?		
	16 Demand and supply of forage		

Type of observation checklist

1. Quality of forage in terms of colour
2. Storage facilities
3. The capacity of the storage facility
4. Price tags
5. Size of the hay bales
6. The compactness of the bales
7. Value addition
8. Type of technology
9. Means of transport

Transporter

1 What type of forage do you transport?
2 What other goods do you transport which are related to dairy subsector?
3 Where do you source?
4 What is the average distance from the producers to customers?
5 Who are the key customers?
6 How frequently do you transport?
7 What are the factors influencing forage transportation?

8 Do you buy and sell or contracted to transport?
9 Do you have a storage facility?
10 What is the buying price of the producer?
11 How much do you charge per kilometre or per unit product?
12 How is the demand for the forage?
13 What is the fuel consumption per unit distance (kilometre)
14 What are the challenge do u face in this sector of transportation?
15 What are the opportunities?
16 Who are the key players in the forage chain?

Observation checklists

1 Size or capacity of the vehicle
2 Type of fuel used (petrol/diesel)
3 State of vehicle e.g. enclosed or open
4 Quality of forage e.g. older bales or fresh

1.4 Traders/ Brokers

1. What type of forage do you sell
2. Where do you buy
3. At what price do you buy and sell
4. Who are the key producers
5. Who are the customers
6. What are the means of transport
7. Do you have the storage facility
8. What is the capacity of the store
9. What is the demand for forage
10. What is your expectation in five years to come
11. Are u aware of climate change
12. What are the challenges in forage business
13. Who are the key players in the chain?
14. What is your relationship with the customers
15. How do you communicate with your customers?

1 .5 Focus Group Discussion (FGD)

Interviews checklist
1. What is the type of forage dairy farmers are using within the area 2. Where do farmers source their forage? 3. At what price do they buy? 4. Do farmers understand the quality and sizes? 5. Who are the key players in the chain 6. Are you aware of climate change? 7. What are the challenges facing forage in your area? 8. How do cooperative help farmers in sourcing forage 9. How do cooperative control the flow of forage in terms of prices and demand 10. How do prices fluctuate 11. Do all farmers have dairy feed stores 12. When do farmers buy most, is it during the wet season or dry season? 13. Scalable practices in the forage supply chain

14. Technologies to maintain the quality of the forage and minimise GHG emission. 15. Possible business models 16. chain governance to scale up climate-smart fodder supply 17. factors influencing forage supply

1. 6 Forage producers farmers

Interview Checklist	Observation list
1. Cost of production 2. Type of forage 3. Production methods 4. Type farm machinery 5. Farm inputs 6. Production capacity 7. Demand of forage	1. Type of farm machinery 2. Type of forage 3. Storage facility 4. Production methods 5. Resources available in the farm **6.** Technologies

2. Emission factors and fractions for estimation of nitrous oxide emissions from fertilizer application.

Emission factors	Description	Value
E_{factor}	Default emission factor for fertilizer, i.e. kg of N_2O-N per kg N applied.	0.01
EF_{leach}	Default emission factor from N leaching and runoff, kg N_2O/kg N	0.0075
$FRAC_{atm, f}$	Fraction of total synthetic fertilizer nitrogen that is released into the atmosphere as NH_3 or NO_x, kg N_2O/kg N	0.1
$FRAC_{leach}$	Fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N_2O/kg N	0.3

Source: Training manual by Shem Kuyah et al 2017

3 Demand and supply

Demand	2	2.5	3	3.5	4.5	5.5	6.5	8	12
Supply	13	9	7	6	5	4	3	2	2

Demand	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
Prices	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

4 GHG emission in Githunguri

Calculations of GHG emission in Githunguri Total member=24,936 Average cows/member=2 Average live weight= 450kg Total number of dairy cows=41,385 cows ……………………………………….county records Manure produced by one cow per day=8% of live weight … ………………..Font-Palma, C. (2019). 3.6= 8 %*450 Dry matter of manure=20% of 3.6Kg manure = 0.72Kg of manure (dry) Total manure produced per day in Githunguri =41,385*0.72 kg dry manure = 29,797.2Kg **GHG emission of manure** 1 tonne of manure produces 33,579g CO2e **……………………** Aguirre-Villegas and Larson, (2017) Total GHG emission in Githunguri= 29.8 tonnes*33579g/ton =1,000,654.2g of CO2-e per day = 1 tonnes CO2-e/day

5 GHG emission for Rhode grass hay production

	F1 Fodder establishment			**F1 Fodder after the establishment**	
Activities	litres of diesel used	GHG emission KgCO2e/l	energy consumption (35.9Mj/l)	GHG emission KgCO2e/lt	Energy consumption
Ploughing	17.29	46.1643	620.711	0	0
1st harrowing	19.76	52.7592	709.384	0	0
Raking	12.35	32.9745	443.365	0	0
2nd harrowing	19.76	52.7592	709.384	0	0
Planting	14.82	39.5694	532.038	0	0
Fertiliser	19.76*	52.7592	709.384	26.3796	367.042
Weeding	9.88	26.3796	354.692	26.3796	354.692
Harvesting	44.46	118.7082	1596.114	118.7082	1596.114
Total bale per hectare		494	494	617.5	617.5
Total	**158**	**422.0736**	**5675.072**	**171.4674**	**2317.848**
Average CO2e per bale		**0.8544 KgCO2e**	**11.488MJ**	**0.27768 KgCO2e**	**3.7536 MJ**

NB: * *Refer to diesel used during topdressing. The cost refers to buying price for both NPK fertiliser and CAN fertiliser used during establishment and topdressing.*
Leasing of land and bush clearing costs were not included, the majority of forage producers owned their lands. Quantification of GHG emission was based on data collected during interviews with forage producer. CO2 footprint derived from fuel used during the production of forage from land preparation, management, harvesting and transportation within the production farms.

6 GHG emission of other related crops

	Yield (kg hectare^{-1})	N-fertilizer (kg hectare^{-1})	GHG-emissions per hectare (kg CO_2-eq. ha^{-1})		
			Conventional production	Reduced tillage	Direct drilling
Oats	3,157	77	1,800	1,720	1,720
Barley	3,380	86	1,930	1,850	1,850
Wheat	3,940	116	2,330	2,250	2,250
Rye	2,619	116	2,270	2,190	2,190

Source: Rajaniemi, M., et al 2011.

7 Fieldwork photos Ngongongeri farm- Egerton and Lalela farm in Narok west

GHG and NH_3 emissions from different manure management practices in small, large, and permitted facilities.

Process	Management Practice	NH_3 g NH_3/ton manure	NH_3 g NH_3/AU/day	GHG manure g CO_2-eq/ton manure	GHG manure g CO_2-eq/AU/day	GHG energy g CO_2-eq/ton manure	GHG energy g CO_2-eq/AU/day	Total GHG g CO_2-eq/ton manure	Total GHG g CO_2-eq/AU/day	Total GHG g CO_2-eq/kg milk
Small farm/solid manure										
Collection	Skid steer	1233	30	7215	173	4745	114	11,960	287	19
	Barn cleaner	1233	30	7215	173	644	15	7859	189	12
Transport to storage	No transportation	0	0	0	0	0	0	0	0	0
	Tanker	0	0	0	0	2418	58	2418	58	4
Storage	No storage	0	0	0	0	0	0	0	0	0
	Below ground concrete	500	12	16,108	387	0	0	16,108	387	25
Land application	Surface application, no storage	1583	38	28,075	674	5503	132	33,579	806	52
	Surface application, storage	1406	34	25,620	615	5503	132	31,123	747	48
Scenarios	*Reference*	*2817*	*68*	*35,290*	*847*	*10,248*	*246*	*45,538*	*1093*	*71*
	Low/high	*2817–3139*	*68–75*	*35,290–48,943*	*847–1175*	*6147–12,667*	*148–304*	*41,437–61,609*	*994–1479*	*65–96*
Large farm/liquid manure										
Collection	Skid steer	404	21	2489	127	1912	98	4401	224	14
	Alley scraper	404	21	2489	127	262	13	2750	140	8
Transport to storage	Pump	0	0	0	0	217	11	217	11	1
	Gravity	0	0	0	0	0	0	0	0	0
Storage[a]	6 month, no agitation, no crust	1283	65	83,825	4275	0	0	83,825	4275	258
	6 month, no agitation, crust	325	17	67,725	3454	0	0	67,725	3454	208
	6 month, agitation, crust	325	17	67,725	3454	48	2	67,725	3454	209
	12 month, agitation, crust	649	33	76,088	3,6880	24	1	76,112	3882	234
	3 month, agitation, crust	162	8	36,393	1856	95	5	36,488	1861	112
Land application	Surface, no agitation, no crust, 6 month	1211	62	14,244	726	2169	111	16,413	837	51
	Injection, no agitation, no crust, 6 month	73	4	17,143	874	3357	171	20,500	1045	63
Scenarios	*Reference*	*2898*	*148*	*100,558*	*5128*	*4298*	*219*	*104,856*	*5348*	*323*
	Low-high	*1778–1760*	*91–90*	*53,126–103,457*	*2709–5276*	*2525–5534*	*129–282*	*55,652–108,991*	*2838–5559*	*171–335*
Permitted facility/liquid manure										
Collection	Skid steer	237	17	1615	113	1534	107	3149	220	11
	Alley scraper	237	17	1615	113	562	39	2177	152	8
Transport to storage	Pump	0	0	0	0	283	20	283	20	1
Processing	SS	0	0	0	0	2853	200	2853	200	10
	AD + SLS	0	0	15,898	1113	(78,541)[b]	(5498)	(62,643)	(4385)	(219)
	SS + SLS	0	0	0	0	4834	338	4834	338	17
	SS + AD + SLS	0	0	15,898	1113	(75,688)	(5298)	(59,789)	(4185)	(209)
Storage	6 month, no crust, agitation after SS	707	50	60,402	4228	10	1	60,412	4229	212
	6 month, no crust, agitation after AD + SLS and SS + AD + SLS	1383	97	10,875	761	10	1	10,885	762	38
	6 month, no crust, agitation after SS + SLS	818	57	36,596	2562	10	1	36,605	2562	128
Land application	Injection after SS + AD + SLS	24	2	12,061	844	11,510	806	23,572	1650	83
	Surface after SS + AD + SLS	390	27	12,062	844	7435	520	19,497	1365	68
	Injection after SS + SLS	36	3	14,292	1000	11,510	806	25,802	1806	90
	Surface after SS + SLS	690	48	14,294	1001	7435	520	21,729	1521	76
Scenarios	*Reference*	*1664*	*115*	*40,450*	*2832*	*(62,351)*	*(4365)*	*(21,900)*	*(1533)*	*(77)*
	Low-high	*2010–1091*	*141–76*	*40,451–52,503*	*2832–3675*	*(70,262)-18,171*	*(4918)-1272*	*(29,810)-70,674*	*(2087)-4947*	*(104)-248*

8 Githunguri Sub-county livestock records

County summaries for livestock population (Numbers) 2018																											
County	Sub-County	Cattle		Sheep		Goats		pigs	Rabbits	Poultry											Donkeys	Camels	Hives				Ostrich
		Dairy	Beef	Wool	Hair	Dairy	Meat			Broilers	layers	indigenous chicken	Turkeys	Ducks	Geese	Guinea fowl	Geese	Pigeons	Doves	Quails			Log	KTBH	Lang	Box	
Kiambu	Githunguri	41,385	0	150	900	356	3204	274	1500	40500		67500	1983	1550	800	No data		No data	No data	No data	537		No data	251			0
	2																										
	3																										
	4																										
2	1																										
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