SUSTAINABLE CARBON FARMING AND CARBON CREDITS BUSINESS MODELS FOR SMALLHOLDER DAIRY COOPERATIVES IN EMERGING ECONOMIES; A CASE OF KENYA.

By

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September 2020

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A Research thesis submitted to Van Hall Larenstein University of Applied Sciences in partial fulfilment of the requirements for the degree of master in Agricultural Production Chain Management (APCM). With specialisation in livestock chains.

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"This research was commissioned by AGRITERRA, in its carbon farming and carbon credits feasibility study project 20at-8613. AGRITERRA is a Dutch Agri-agency based in Arnhem, a specialist in business development for cooperatives and farmer organizations in developing and emerging economies".

September 2020

Van Hall Larenstein University of Applied Sciences, Velp.

The Netherlands

Acknowledgement and dedication

First and foremost, I would like to thank Almighty God for giving me this opportunity and good health throughout my studies.

Thanks to you, Edith Heiness Representative & Country Director of United Nations World Food Programme Rwanda as my previous employer. Much appreciation to your outstanding leadership and your support for my studies; thanks once again for the waiver.

Special gratitude to the Government of the Kingdom of Netherlands, through the Orange Knowledge Programme (OKP) for offering a scholarship to further my studies in the Netherlands. I would like to thank the entire staff at Van Hall Larenstein University of Applied Sciences for the support extended during the whole study period at the University.

Professor Robert Baars, you taught me not only how to write professionally but also how to think critically throughout your guidance in this thesis trajectory, thanks for everything.

Much appreciation for Bertken de Lee on behalf of the Agriterra team, especially the Kenya team (Mary and Hillary) thanks for your support, also for considering me to be part of the research project 20at-8613 of carbon farming and carbon credits feasibility study.

I would like to appreciate the support and comfort of my Agriterra project teammates Ashiraf MIGADDE and Marlies van den NIEUWENHOF. Also, all interviewed people for their time, hospitality and efforts to make this research successful. My fellow students, I also appreciate your determined effort for ensuring my studies goes smoothly.

Finally, at any step of this hectic journey, wouldn't have been easy without the prayers and support of my family member and my mother. To my caring, loving and supportive wife UMUTESI Neema Grace, deep gratitude. Your support and prayers during tough times are much appreciated. This great achievement is dedicated to my lovely firstborn daughter Rugwegwe T. Novella; “thanks papa”, dad loves you.

Rugwegwe Olivier N.

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List of conversion and abbreviation/acronyms

1 ha = 2.47 acres
CAT: International Centre for Tropical Agriculture
CER: Certified Emissions Reduction
CDM: Clean Development Mechanisms
CH4: Methane
CO2: Carbon dioxide
CSA: Climate-Smart-Agriculture
DOE: Designated Operating Entity
EU ETS: European Union Emissions Trading Strategy or Directives
FAO: The Food and Agriculture Organization of the United Nations
GoK: Government of Kenya
HFCs: Hydrofluorocarbons
IPCC: Intergovernmental Panel for Climate Change
KACP: Kenya Agriculture Carbon Project
KALRO: Kenya Agricultural and Livestock Research Organisation
KEBS: Kenya Bureau of Standards
KDB: Kenya Dairy Board
KP: Kyoto Protocol
MFI: Micro-finance Institutions
MoALF: Ministry of Agriculture, Livestock, and Fisheries
NEMA: National Environmental Management Authority
NGO: Non-Governmental Organization
N2O: Nitrous oxide
NH3: Ammonia
OTC: Over the Counter
PFCs: Perfluorocarbons
PDP: Project design documentation
RGGI: Regional GHG Initiative
SACCO: Saving and Credit Cooperative Organizations
SALM: Sustainable Agricultural Land Use management
SF6: Sulphur hexafluoride
SPSS: Statistical Package for Social Science
VER: Voluntary Emission Reductions
Via: VI-Agroforestry
VCS: Verified Carbon Standards

Abstract

The dairy sector in Kenya is one of the pillars for smallholder farmers' livelihoods through the generation of income, employment, and food to 2 million people across the dairy value chain although the sector is still vulnerable to climate change. Agriterra stimulates climate-smart agriculture and carbon farming to support farmers and their cooperatives to be resilient towards climate change by focusing on enhanced productivity and increasing farmers cooperatives business model. Therefore, Agriterra wanted to know the dairy-related carbon farming practices adopted by cooperative members in Kenya and the business model of linking carbon farming practices to the carbon credits schemes for the sustainable service provision and carbon farming adoption among cooperative members. This research was carried out to advise Agriterra on the business model of integrating carbon farming practices into carbon farming credits for dairy farmers in Kenya. To understand the concept of carbon farming practices, related benefits, and the integration model to carbon credits schemes; the study employed literature review, online farmers survey, and online key-informants interviews.

The study highlighted that farming practices such as planting quality fodder, intercropping trees on cropland or livestock, manure storage and producing biogas through bio-digesters have been practised among dairy cooperatives farmers in Kenya and were backed by sciences to be the potential dairy carbon farming practices in dairy. The study identified the existence of carbon credits schemes in Kenya and the viability of integrating smallholder farmers' carbon farming practices into carbon credits schemes. The study determined that carbon credits dividends are almost insignificant to farmers, but carbon farming practices have severe positive impacts on the ecosystem and farmers livelihood.

The analysis of both Agriterra and clients cooperative business models indicated that Agriterra is well-positioned to promote farmers carbon farming practices and increase the value proposition of its dairy clients, having a local presence and a sound knowledge of cooperatives and dairy farming. However, Agriterra needs to use its extensive experience of lobbying and advocacy for policy change to raise funds that can finance carbon farming and carbon credits projects among dairy cooperatives clients. Also, invest in farmers carbon farming awareness. The new business model will increase the cooperatives value proposition and revenue streams from carbon credits while Agriterra will strengthen its brand name and trust with clients cooperatives. Furthermore, the new business model will reduce farmers GHG emissions and make their farmers more resilient to climate change.

Keywords: *Carbon farming practices, carbon credits, climate-smart dairy, business model.*

CHAPTER 1: GENERAL INTRODUCTION

1.1. Introduction

Agriterra is a Dutch Agri-agency based in the city of Arnhem in the Netherlands that provides business development services to ambitious cooperatives and farmer organisations in developing and emerging economies and commissioned this research. Advice is provided in the form of training through locally hired business advisors and by linking experts from Dutch and international farmer organisations and (cooperative) companies; the so-called Agri-pool experts. The Agriterra service provision approach is based on three-track such as making cooperatives bankable and create real farmer-led companies, supporting organisations to improve extension services to their members, and enhancing farmer-government dialogues (Leede, 2020).

Agriterra supports client's cooperatives and farmer organisations by providing them meaningful and reasonable advisory services to improve the business performance. The advisory services include organisational capacity building such as financial management, good governance, and business development. Part of business development concentrates on production and productivity while embedding the promotion of climate-smart solutions/approaches allowing for ecologically sustainable productivity (Leede, 2020).

1.2. Background

The world's food system is facing unprecedented challenges as global climate change is re-shaping agricultural production where the food system must make sure the growing population has access to food and therefore the needed nutrition values (The Economist Intelligence Unit, 2015).

Climate change is predicted to harm a minimum of 22% of the world's most vital crops and livestock production, and 56% of all crops in low-income Africa countries by 2050 (Wollenberg et al., 2011). There is increasing competition for land, water, energy, and other inputs into food production where it increases agriculture challenges, mainly in emerging economies (Campbell et al., 2014) Thus, many researchers have suggested several potential climate-smart agriculture adaptations, and mitigation practices scale back agriculture climatic risks (FAO, 2019a).

The agriculture sector emits both CO_2 and non-CO_2 GHG (Nitrogen in Ammonia (N_2O), and Methane (CH4) expressed in CO2-equivalent (CO2-eq) through land-use change and forestry and livestock (CERRI, 2010). The livestock sector represents 14.5% of GHG emissions estimated at 7,100 million tonnes of CO2-eq per annum (Gerber et al., 2013). However, the concept of climate-smart agriculture has been introduced to mitigate the agriculture-related emissions with the purpose to achieve development sustainably based on three pillars:

1. Increasing agricultural productivity and incomes sustainably;
2. Building resilience on climate change adaption;
3. Whenever possible, reducing or removing GHG emissions (FAO, 2013).

The concept of carbon farming practices is one set of the big umbrella of climate-smart agriculture that deals with reducing or removing GHG emissions. It is believed that improved land management, water management, manure management, and forest management could be the most appropriate carbon farming practices (Lal et al., 2011).

In developing countries, cooperatives are a business model for smallholder farmers and perform as both social and economic networks that are focused on the low segment of the population (Sumelius et al., 2013). Cooperatives play a crucial role in food and feed production and commercialization processes (Giagnocavo et al., 2017). It has been insisted that cooperatives and stakeholders' business models design through shared values can play a crucial role to unravel social and environmental issues around them (Bardouille, 2013).

Food or feed production and global climate change are interlinked factors that require to be addressed simultaneously by increasing resource efficiency in agriculture and building smallholder farmers' sustainability (FAO, 2019a). Promotion of climate-smart agriculture and carbon farming has gained significant attention among emerging economies through improved farming for resilience and reducing GHG emissions (Mwongera et al., 2017). However, it is still unclear how or to what extent smallholder farmers in Kenya are practising carbon farming and the way farmers might be compensated for their good practices.

1.3. Research problem.

The agriculture sector in Kenya is dominated by 75% small scale production and holds a big part in the Kenyan economy, accounting for over 25% of the gross domestic product. Moreover, the sector represents 65% of total exports and 18% of formal employment, where livestock subsector employs 50% of the agricultural labour force. However, agriculture is still vulnerable to climate change since 98% is predominantly small-scale and more dependent on climatic conditions that influence livestock production (FAO, 2016).

Several carbon farming initiatives such as the livelihoods Mount Elgon project have been implemented in Kenya to mitigate the effects of climate change through financing smallholder farmers to improve soil and land management production systems (Tennigkeit et al., 2013). Besides, carbon credits schemes have been developed to compensate agriculture carbon practices through carbon credits, since it is believed that compensation of farmers' carbon farming practices can stimulate GHG emissions reduction and hence, making their farms more resilient to climate change and increase productivity (Leede, 2020).

Agriterra as a problem owner in this research stimulates climate-smart farming and carbon farming to support farmers and their cooperatives to be resilient towards climate change by focusing on enhanced productivity, practising adaptation measures, and identify and apply mitigation practices both at farmers and cooperative level (Leede, 2020).

Therefore, Agriterra wanted to know the dairy-related carbon farming practices adopted by cooperative members in Kenya and the business model of linking carbon farming practices to the carbon credits schemes for the sustainable service provision and carbon farming adoption among cooperative members.

1.4. Research objective

To advise Agriterra on the potential carbon farming practices and assess the viability to be linked to carbon credits schemes as a successful business model among dairy cooperative members in Kenya.

1.5. Research questions

Main question 1;

What are the positive effects and trade-offs of carbon farming practices linked to smallholder dairy farmers in Kenya?

Sub questions;

1. What are the existing carbon farming practices applied by dairy farmers cooperatives in Kenya?
2. What are the financial and ecological benefits of carbon farming practices?
3. What are the possible trade-offs of carbon farming practices?

Main question 2;

What is the best way to integrate carbon credits schemes with current agricultural cooperative business models?

Sub questions;

1. What are the existing carbon credits schemes?
2. What are the cooperative entry requirements for carbon credits schemes?
3. What accounting methodologies and standards are used in the carbon credit schemes?
4. What are the risks associated with carbon credits schemes?

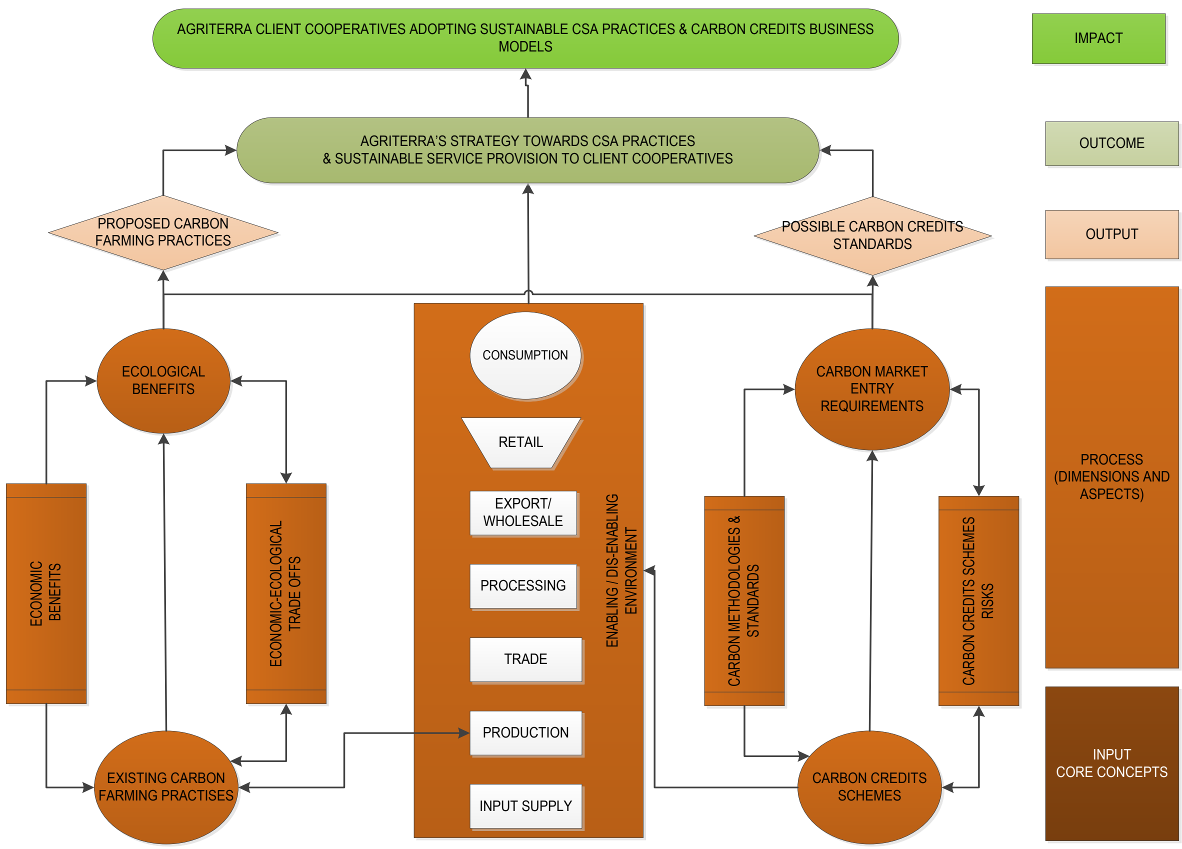
CHAPTER 2: LITERATURE REVIEW

This chapter covers the conceptual framework, definition of key concept terms, dairy farming systems, climate-smart dairy, carbon farming practices, lessons learned from other carbon projects, and operationalization of the study. The section of dairy farming systems, climate-smart dairy, and lessons learned from other carbon projects have been presented in this part due to its relation to dairy carbon farming practices and are based on the literature. Besides, the carbon credits schemes concepts have been shown in the finding parts and were also largely based on literature.

2.1. Conceptual framework

In this study, the core concept is derived from climate-smart dairy with two main ideas which are carbon farming practices and carbon credits schemes. It implies the identification of carbon farming practices among the targeted cooperative's farmers while considering financial and ecological benefits, and carbon farming practices trade-offs. On the other hand, the study dig-deeper into the concept of carbon credits schemes for the applied carbon practices by identifying market standards, cooperative entry requirements, risks related, and certification procedures for projects in emerging economies. In this study, concepts helped to identify the carbon farming practices and integration of business models, as shown in figure 1.

Figure 1: Conceptual framework



Source: Author, 2020

2.1.1 Definition of key concepts

Carbon farming: Carbon farming describes a collection of eco-friendly techniques that can increase carbon sink into the soil or abatement activities leading to a reduction in GHG emissions (Sharma, 2015). In this study, carbon farming is defined as dairy farming practices proven as CO_2 eq mitigation measures.

Carbon sequestration: Toensmeier, (2020) defined carbon sequestration as regenerating soil by increasing the carbon stored in the soil in the form of organic matter and by increasing the carbon that is held in perennial biomass through photosynthesis. Removed carbon dioxide in the atmosphere and stored in soils and biomass, makes farms and land more resilient to climate change.

Greenhouse gas: Greenhouse gas is characterised as all gasses both natural and anthropogenic, that retain and transmit radiation at specific wavelengths inside the range of warm infrared radiation released by the Earth's surface, the air itself, and by clouds. Greenhouse gas is composed of carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) (IPCC, 2015b).

Carbon Credit: Carbon credit is defined as a unit of payment made by an emitter of carbon (a power plant, mine, or oil refinery) to the carbon project developers that can sequestrate carbon (Curran et al., 2012).

Climate change: The phenomenon of climate change is expressed as changes in the regular length seasons, global warming, and disappearance of some ecosystem nature as an effect of GHG emissions. Scientists attribute the temperature increase to a rise in carbon dioxide and other GHG's released from the burning of fossil fuels, deforestation, agriculture, and other industrial processes (Schahczenski & Hill, 2009).

Business Model: Business model is defined as a template that describes the organisation transactions with all of its external components in factor and product markets (Zott & Amit, 2010)

Smallholder farmer: The term smallholder farmer concerns individual crops, pastoralists, fishers, forest keepers who manage a small portion of land varying between less than one to 10 hectares of land (FAO, 2012). In Kenya specifically, smallholder and poor farmers, are not fully integrated into markets, choose to produce their leading staple food but also can have a wide range of foods, often more comprehensive than larger and commercialized farms (FAO, 2015).

Offsetting: In the field of carbon emission, the term offsetting is referred to as the unit of GHG reduction, avoided or sequestered to compensate for emissions produced elsewhere in the world (Goodward & Kelly, 2010).

In-setting: The term, carbon in-setting is referred to as the approach of which many organizations apply to reduce their carbon footprint with their own or partners' value chain (Malin et al., 2013).

Carbon pollution swapping: Can be defined as the increase of rot on one aspect as results of mitigation measures introduced somewhere else (Brennan et al., 2015)

Carbon emission additionality: Is defined as the determination of added value by a proposed carbon project compared to what would have happened if the project wouldn't have taken place (Gillenwater, 2012).

Carbon emission registry: The carbon emission registry is the process of accrediting a given unique serial number to carbon credits for easy tracking during trading. The registry is done on both voluntary markets as well as compliance markets by certification standards (Marketplace, 2012).

Carbon emission retirement: "The point at which a carbon credit that is purchased voluntarily is permanently set aside by its owner in a designated registry and the carbon credit's unique serial number out of circulation". Carbon retirement is done to avoid double carbon accounting and ensures that credits cannot be re-sold (Marketplace, 2012).

Carbon project validation: Is the process of accreditation of information on project design such as baseline results, monitoring schemes, and methodologies for calculating emission reductions for carbon offset projects (Marketplace, 2012).

Carbon project verification: Is the process of or to verifying if the project's stated environmental, social and other co-benefits have been achieved, the measurement is done by quantifying the number of actual emission reductions against credits to be issued for the offset projects (Marketplace, 2012).

2.2. The dairy farming system in Kenya

In Kenya, dairy cattle production is the second contributor to the agriculture sector, where dairy produced 76% of 4.48 billion litres of milk in 2014 (FAO, 2019b). Milk production in Kenya is one of the pillars for smallholder farmers' livelihoods through the generation of income, employment, and food to 2 million people across the dairy value chain (FAO & New Zealand agricultural greenhouse gas research centre, 2017).

Meul et al., (2012) have conceptualized dairy farming systems from the perspective of labour efficiency, environmental impact, animal welfare integrated into ecological, economic, and social aspects. The farming systems are intended to ensure safe and desired milk and milk products and also provide the future sustainability of dairy farms from economic, social, and environmental perspectives (FAO and IDF, 2011). Many academicians have discussed the similarities and differences of dairy farming systems where (FAO, 2019b) and (Meul et al., 2012) have identified three dairy production systems in Kenya; intensive, semi-intensive and extensive grazing systems. FAO, (2019b) have classified dairy population into farming systems categories where intensive hold 40%, semi-extensive grazing comprising 45% where extensive systems hold 15% of all dairy farms.

Extensive grazing management is defined as a livestock feeding system where animals are raised on natural grasslands or any other sorts of natural vegetation (FAO and IDF, 2011). Farmers mostly practice extensive grazing where there is enough land space; however, such a system is gradually declining in Kenya due to land scarcity and the increase in demand for milk and other dairy products (FAO, 2019b). The dairy products from extensive grazing system are perceived as high quality (organic, low use of antimicrobials) and are often sold in a niche and high-quality markets with milk production ranging from 4-11 litres of milk per cow per day (FAO, 2019b). However, the system is constrained by seasonality in feed availability following rainfall and declining of communal grazing fields as a result of increasing human settlement and development (FAO, 2019b).

The semi-extensive grazing system is referred as the mixed of the intensive and extensive grazing system based on seasonal variation in pasture and water availability where milk production in the system varies between 6-9 litres of milk per cow per day. It is believed that the system has challenges of feed quality and availability.in addition to the limited access to Artificial Insemination (AI) services constrains breed improvement and productivity (FAO, 2019b).

The intention of dairy automation and increased productivity, farmers in urban and peri-urban areas are adopting intensive grazing system or Zero-grazing where animals are kept inside the ban along the year and most of the time animals are fed artificial or processed forages (Meul et al., 2012). In Kenya, milk production in the system ranged from 15-30 litres of milk per cow per day. However, the system is constrained by the low and high price of feed and inadequate veterinary services to tackle the significant diseases which prevent small scale farmers from improving on their financial and infrastructural capabilities (FAO, 2019b).

In Kenya, despite the importance of the dairy sector for farmers livelihood, however, the industry is responsible for about 12.3 million tonnes CO2 eq, dominated by 95.6% of CH_4 of the total GHG emissions mainly from ruminants enteric fermentation (FAO & New Zealand agricultural greenhouse gas research centre, 2017). Therefore, the concept of climate-smart agriculture was introduced in Kenya to mitigate the impact of climate change and improved farmers livelihood (FAO, 2016). Besides, it is believed that carbon farming practices vary per farming system, land size differences, dairy cow breed, herd size, and other factors of production.

2.3. Climate-smart dairy practices

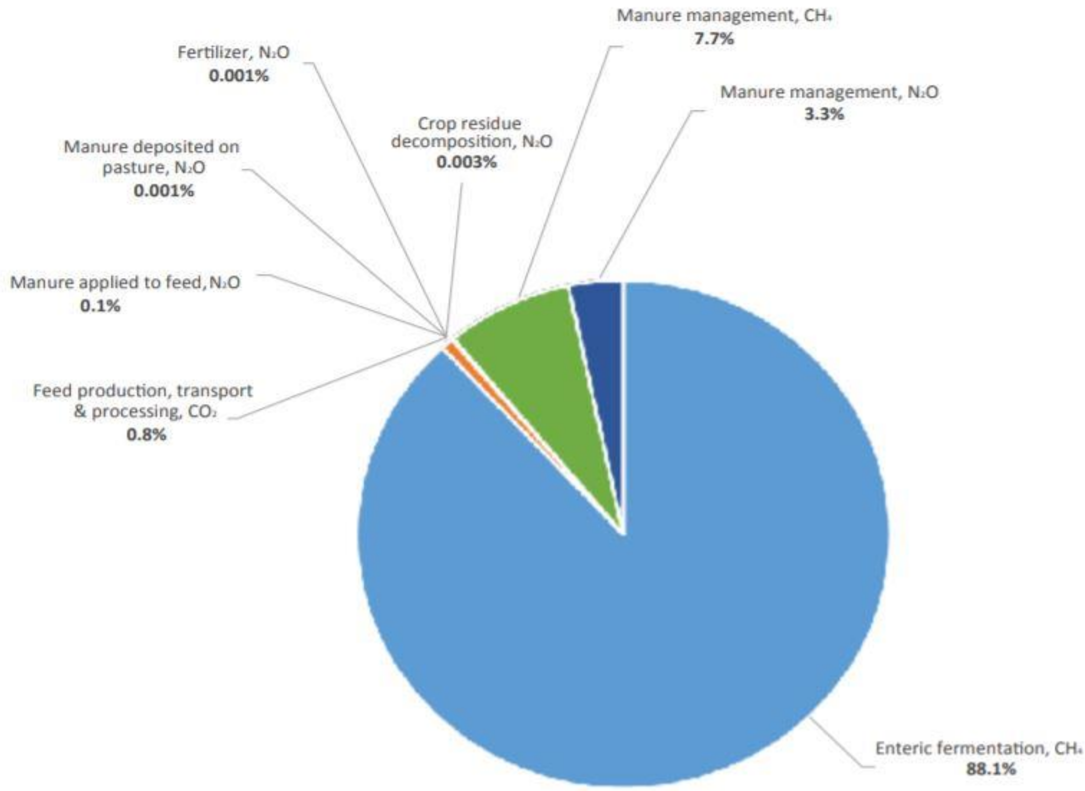
The concept of carbon farming and climate-smart agriculture are interlinked concepts to dairy carbon farming practices. The idea of CSA is intended to address food security and climate challenges by integrating economic, social, and environmentally sustainable development aspects (FAO, 2013). For African countries to acquire the potential benefits of CSA, real actions must be taken, such as supportive policy framework formulation, promote and facilitate appropriate technologies adoption for farmers. Also, scale-out CSA from the farm level to the agricultural landscape level; and implementing effective risk-sharing schemes for farmers and other stakeholders (Williams et al., 2015).

For the Kenyan government to solve the dual challenges of food security in the face of the current climate changes, has set in place a climate-smart agriculture implementation framework 2018-2027. The framework was developed with the purpose to promote sustainable agriculture and ensures food security in line with Kenya's vision 2030 (MALFI, 2018).

Climate-smart practices in dairy are categorized as all adaptation and mitigation practices to meet future dairy food and nutrition requirements by reducing emissions (Pampi & Archana, 2016). Adaptation practices in dairy include the keeping of varieties or breeds with resistance to numerous stresses (drought, abiotic, and biotic). Besides, the concept stimulates the use of productive breed, improved feed quality to increase milk production, and diversify sources of revenues to improve farmers' livelihoods (FAO, 2016). Whereas, the climate-smart dairy mitigation practices are regarded as all practices that reduce GHG emissions and practices that sequester CO_2 equivalent in the atmosphere (Lal, 2010).

In Kenya specifically, the concept of climate-smart dairy adaption and mitigation measures have been adopted where keeping productive cattle breed (Friesians), agroforestry, use of cover crops, intercropping, and practising mulching as conservation agriculture were identified in some regions of the country. Besides, the use of free emissions equipment to deliver milk or produce water such as the use of bicycles and electric water pumps has been noted despite the little awareness of climate-smart practices among farmers (Kiiza, 2018). Despite the adoption of climate-smart practices in Kenya, the agricultural sector is the largest source of total GHG emissions by 58.6%, and livestock-related emissions account for the overwhelming majority of 96.2% of the agriculture emissions as highlighted in figure 2 below.

Figure 2: Kenyan dairy GHG emissions



Source: FAO & New Zealand agricultural greenhouse gas research centre, (2017) ©

However, In Eastern Africa, the concept of climate-smart agriculture and carbon farming practices such as "integrated crop-livestock management, manure management, agroforestry, improved grazing, and improved water management" have been adopted and are gaining high interest among farmers (FAO, 2016).

2.4. Carbon farming practices

Carbon farming practices have been thought of as a critical approach to mitigate agricultural GHG emissions. Agriculture, forestry, and other land use have been proven to reduce emissions from agricultural production and sequester carbon in natural sinks and are referred to as carbon farming (Tang et al., 2018).

According to FAO & New Zealand Agricultural greenhouse gas research centre, (2017), it is clear that CH_4 from enteric fermentation and manure management poses an immense burden on Kenyan dairy counting for 99.1% of total dairy GHG emission. It is hard to suggest climate-friendly techniques and carbon farming practices to mitigate climate change that can reduce or sequestrate GHG emissions in dairy. Following the recommendation of (IPCC, 2015b) and (World Bank; CIAT., 2015) on the climate-smart practices related the research has picked the reduction of GHG emissions in dairy, improved feeding, improved manure management, and agroforestry practices as most striking carbon farming practices in dairy.

Carbon farming practices dimensions

i. Improved feeding
ii. Improved manure management
iii. Agroforestry

2.4.1 Improved feeding

In this part, literature has coved carbon farming practices related to improved feeding such planting quality fodder, improved forage storage, rotation grazing and improved diets for digestibility.

Carbon farming practices related to improved feeding involve improved pasture species, improved grassland management, forage mix and greater use of supplements locally available (FAO, 2016). In the United States of America, planting improved quality fodder and legumes on grazing pastures have been suggested as the best option and less costly carbon farming practices to mitigate enteric fermentation emissions (ICF International, 2013). The FAO, (2016) has recommended the number of dairy carbon farming practices to improved cattle feeding to mitigate CH_4 from enteric fermentation that can be practical in the East African countries, including Kenya such as:

- ✓ Quality fodder production (Napier grass, Rhodes grass, Brachiaria grass, Columbus grass, forage sorghums, Desmodium, Dolichos lab and lucerne (alfalfa) and
- ✓ Feed conservation by baling hay and making silage" (FAO, 2016).

In Kenya, planting high-quality grass such as Napier grass, Rhodes grass on the grazing pasture, or mixt with crops has gained high interest among smallholder farmers (Livelihoods Funds & VI Agroforestry, 2016). The use of high-quality forages such as Napier grass that can be grown in most Kenyan ecological zones can be presented as a feasible carbon farming practice since it has been proved to reduce GHG emission by boosting dairy cows' productivity (Negawo et al., 2017).

Despite the availability of high-quality forages in Kenya, Serem, (2019) criticised forages storages which diminish the quality of the forages. Besides, farmers in Kenya have been facing feed shortages in lean seasons due to lack of proper storage of forages where forages lose their high-quality nutrients leading to high waste hence the production of GHG emissions (Serem, 2019). Therefore, improving forages storage and making silage for conservation through cleaned and covered storages to maintain quality forages can be noted as carbon farming practices.

In addition to planting high-quality fodder and proper forage storages, improved grazing land management through rotation grazing have been noted by The Northern Rangelands Trust, (2015) as a carbon farming practice practical in Kenya since it contributes a lot for enteric fermentation CH_4 emission reductions, soil restoration, reduced soil erosion, and improved productivity of grassland (The Northern Rangelands Trust, 2015). Rotation grazing can be defined as the management movement of herds or planned movement grazing on paddocks. The planned move of cattle allows the recovery of grass banks that can be used during the lean season or droughts (The Northern Rangelands Trust, 2015). The concept of carbon farming rotation grazing allows fodder growth rates; hence achieving the fodder balanced dietary energy for extensive grazing farming systems. However, to successfully practice rotational grazing system in Kenya as a carbon farming, might depend on the farmers land size, climate and soil type, and human management of the farmers.

Kiiza, (2018) pointed out that farmers have access to the quality forages such as Napier grass, Rhodes grass, Brachiaria grass, although dairy cows are fed only one forage due to low feed diversification. Caro et al., (2016) mentioned that poor feed diversification leads to the release of GHG emission because of digestive processes or unbalanced diets to meet the feed intake of ruminants.

In China, several studies have demonstrated that increasing dietary feed contents by adding concentrate supplementation would increase cattle's nutrient digestibility hence reduces CH_4 emission (Dong et al., 2019). However, the use of complementary feeding might not be efficient carbon farming practices in developing countries like Kenya because of the high cost of access to the local market.

Ali et al., (2019) mentioned the use of improved crop residues such as by-products of sweet potato, can improve diet digestibility, thus reducing cattle's N_20 and their CH_4 emissions per unit of digested feed in India. Therefore, the use of improved crop residues such as sweet potato and maize leftover can be practical to Kenyan farmers because of integrating dairy and crop farming. Also, complementing quality feed with concentrate and industrial residues can be documented as carbo farming practice.

Moreover, planting quality fodder involve soil management practices such as tillage operations which are conventionally used for loosening soils to grow fodder crops. But long-term soil disturbance by tillage is believed to be one of the significant factors reducing soil organic matter in agriculture (Ghimire et al., 2012). It is believed that reduced tillage or reduced soil disturbance while planting fodder provides soil water available for the plants, which in turn stabilize soil fertility (Rosa-Schleich et al., 2019). However, planting quality fodder for improved feeding in the United States of America have presented high uncertainty in the efficacy because of the dependency on livestock type, animal life stage, and farming systems such as extensive grazing, semi-extensive grazing, or intensive grazing (ICF International, 2013). In Kenya, farmers' land size and ecological zones present the burden for planting quality fodder, and rotation grazing as carbon farming.

2.4.2 Improved manure management

In this part, literature has coved carbon farming practices related to improved manure such as manure storage and manure management through bio-digesters.

The most carbon farming practices related to manure management include manure storage, covering manure storage, using solids separator, proper time of manure application, the use of bio-digesters, and improving animal nutritional deities (Rojas-Downing et al., 2017). Emissions from manure management, especially NH_3 and N2O emissions, came in large part of the manure in liquid form and deposited on pasture (FAO & New Zealand Agricultural Greenhouse Gas ResearchCentre, 2017).

Manure storage, manure treatment, and manure application have a strong influence on the losses of nitrogen, phosphorus, and carbon from manure which are released in the air in the form of N_20, CH_4, and NH_3 emissions. Besides, the release of N_20, CH_4, and NH_3 emissions in the atmosphere have presented a high negative impact on climate change and the increase in temperature (De Vries et al., 2015). However, several carbon farming and technologies to mitigate manure related emissions have been presented In the Netherlands, such as manure storage, manure treatment, and manure application (De Vries et al., 2015).

Applying wet manure from animal houses on pastures brings invisible bacteria in soil and urinary nitrogen components transform into ammonium, which releases N_2O and NH_3. Manure management through manure storage to reduce liquid matter in the soil reduces the release of N_2O and NH_3 emissions (Burg et al., 2018). In Switzerland and Russia, several studies have associated 99% of NH_3 emissions mitigation through separation between urine and faeces which can serve as manure carbon farming where manure faeces separated from urine avoids the contamination of manure carbon against urea which releases NH_3 and N_2O (Vaddella et al., 2010).

The application of manure belts that separate manure from urine in the animal house for intensive grazing farmers is an efficient way for farmers in the countries where the technologies can be applicable (Koger et al., 2014). However, the application of manure belts that separate manure from urine cannot work in Kenya, where farmers do not have cattle houses.

Vaddella et al., (2010) pointed out that carbon farming related to proper manure storage such as manure stored in cold places, and manure storage covered can reduce NH_3 production in Switzerland. Also, De Vries et al., (2015) suggested that covering manure storages have proven the possibility of lowering manure odour and NH_3 emission up to 95% in the Netherlands. Carbon farming practice of storing manure can be applicable for farmers with intensive grazing in Kenya regardless of the high labour intensive to keep manure manually. Therefore, manure storage to reduce urine from faeces can be presented as carbon farming since would reduce the further release of N_2O, NH_3 CH_4, and into the atmosphere (Dijkstra et al., 2013). In addition to manure storages, manure treatment through bio-digesters for biogas production can be noted as carbon farming practices since it reduces the further release of emissions.

Manure management and application count for more than 11% of GHG emissions in Kenya, but it holds a potential on the ecosystem and farmers' livelihood once it is treated and applied efficiently (FAO & New Zealand agricultural greenhouse gas research centre, 2017). Manure treatment through anaerobic digestion or bio-energy is produced from digestion leading to the reduction of CH4 emission to the atmosphere during storage and reduces the need/use of fossil energy (De Vries et al., 2015). Producing renewable biogas can be an essential carbon farming practice for mitigating CH_4, N_2O, and NH_3 emissions from manure storage through bio-digesters, hence producing biogas as an alternative source of energy farmers (Burg et al., 2018). However, manure treatment through bio-digesters, the slurry can cause contamination of surface water, leakage of nitrates, degradation of natural resources, and GHG in the form of N2O and other toxic gases (Forabosco et al., 2017). Besides, the use of bio-digesters requires more and massive investment sometimes unfordable to small scale farmers, and many scientists have stressed the incorporation of policies that support farmers' incentive adaptation (Rojas-Downing et al., 2017). The practices related to manure storages are less costly to farmers in comparison to the use of bio-digesters, even though they require high labour intensive for farmers.

2.4.3 Agroforestry

Agroforestry is understood to be the integration of trees, and shrub planting, crops, or livestock on the same land for economic, environmental, and social benefits (FAO, 2008). Agroforestry is a broader concept in livestock and has different practices with different appellations such as Silvopastoral which involves integrating forestry on grazing pasture or rangelands. At the same time, Agrosylvopastoral consists of the combination of dispersed trees on croplands used for grazing after harvesting (FAO, 2008).

Trees agriculture in Kenya has been developed for more than four decades and is believed to have many benefits for smallholder farmers, with the potential to mitigate any damages caused by the change in the environment and increase farmers' income (Hughes et al., 2020). FAO, (2008) has presented multiple Agroforestry benefits for farmers and on the ecosystem in the form of economic, environmental, social, land use, and cultural services as of figure 3.

Figure 3: Agroforestry services.

Economic services	• Diversification of economic activities • Diversification of agricultural revenues • Increase in yield from conventional agricultural systems • Reclamation of fragile or marginal lands
Environmental services	• Increase in plant and animal biodiversity • Decrease in wind and water erosion • Improvement in soil fertility • Improvement in soil hydrology regimes • Mitigation of air, sound and odour pollution • Water treatment • Carbon sequestration and storage • Reduction in deforestation • Improvement in microclimates • Mitigation of climate change impacts on agriculture
Social services	• Job creation • Food security • Landscape enhancement • Improvement in public opinion regarding agricultural and forestry activities
Land use services	• Diversified land use • Use of marginal lands (abandoned agricultural land, hill slope plots, etc.)
Cultural services	• Use of local and indigenous knowledge

Source: (FAO, 2008)

Intercropping proven high nitrous fodder trees or fodder banks such as Calliandra, Sesbania sesban, Gliricidia sepium, Moringa oleifera, and Cajanus cajan on the grazing land or crop; farmers can produce quality fodder, hence reducing the further release of CH_4 through improving cattle digestibility (Tennigkeit et al., 2013). Besides, it serves as carbon farming by capturing carbon from the atmosphere through photosynthesis and storing it in biomass and soil (Reppin et al., 2020).

In Kenya, farmers can apply Agroforestry in the form of timber trees, fruits trees, shading trees on their farms such as Grevillea robusta, Carica papaya, and Markhamia lutea that can be planted along farms boundaries, or around their houses which can benefit them financially and ecologically (Hughes et al., 2020). However, only a few farmers are aware of which quality trees can grow on their land and still facing the challenges of access seeds or nursery. Therefore, FAO, (2016) have suggested fodder shrubs and agroforestry trees nurseries establishment and management for the sustainable agroforestry and improved landscape management.

Mulching trees increases, economic and environmental benefits to agroforestry and sustain landscapes (Chalker-scott, 2016). Mulching is generally defined as covering the soil through crop residues, grass, or plastic covering (Chalker-scott, 2016).

In South Africa, several studies have proven mulching or soil cover as one of the most effective practices that help to increase soil organic matter and improves soil fertility, hence increasing crop productivity and other environmental benefits (Mgolozeli et al., 2020). Therefore, mulching can be noted as another carbon farming practice related to land management due to it ecological benefits which have been found to conserve water and soil, add organic matter and nutrients to the soil, regulates the soil temperature, serves as weeds control, and reduce the use of chemical pests (Mgolozeli et al., 2020). However, mulching is not a common carbon farming practice related to dairy or livestock. Also, there is a highly competitive use crop residue for feed, to sell, or for mulching among smallholder farmers (Mgolozeli et al., 2020).

As presented in this part, agroforestry and mulching have been adopted by many researchers as GHG emissions mitigation measures and considered as carbon farming practices on both crop and livestock agriculture (Lal, 2010). Besides, both practices are widely adopted in Kenya and practical for smallholder farmers despite high labour intensive for mulching applications.

2.5. Lessons learned from Livelihoods Mount Elgon project implemented in Kenya.

Several climate-smart adaptation or carbon farming projects in agriculture and dairy specifically have been adopted and implemented in Kenyan by different project developers.

In the year of 2009, the Livelihoods Mount Elgon project was the second smallholder agriculture carbon offsetting and carbon payments project initiated in Kenya. French companies such as Danone, Crédit Agricole, Hermès, Michelin, SAP, Schneider Electric, and Voyageurs du Monde financed the project through its livelihoods carbon fund in collaboration with the Swedish International Developments Cooperation Agency (SIDA). The project is implemented by the Swedish NGO Vi Agroforestry (Via), Livelihoods carbon fund, and Brookside Dairies Ltd (Livelihoods Funds & VI Agroforestry, 2016). The project issued the first carbon credit payments to participating farmers in February 2014 (Nord, 2014).

The second phase of the project had 15 cooperatives with a total of 30,000 smallholder farmers of which 15,000 crops farmers and 15,000 dairy farmers organized in 1,200 groups from Mount Elgon region in the districts of Kitale and Bungoma located in western Kenya (Livelihoods Funds & VI Agroforestry, 2016).

The Gold Standard approved the carbon project measurement in 2014, and the World Bank carbon fund has committed to buying 35,000 credits every year for nine years for 4 US$/tCO2e through the emissions reductions purchase agreement that was signed in November 2010 (Lee et al., 2015). However, the first payment of carbon credits was scheduled for 2012, but gains were delayed for two years due to carbon sequestered verification problems. Besides, the delivered carbon payment was at 2.40 US$/tCO2e to each farmer on average, less than expected of which Vi Agroforestry kept 40% to cover the costs of the project, and the remaining 60% of the carbon payment belongs to the community group and some groups distributed it to individuals. In contrast, others kept it at a community-group level (Lee et al., 2015).

Lessons learned: This region was chosen based on multiple challenges such as deforestation, threats of the watersheds, inefficient agricultural practices, uncontrolled grazing, and soil erosion which had a direct impact on biodiversity, soil fertility, and the regional ecosystem. Besides, low milk production and crop yields and poor quality of produces for smallholder farmers in the region coupled with little access to market (Livelihoods Funds & VI Agroforestry, 2016).

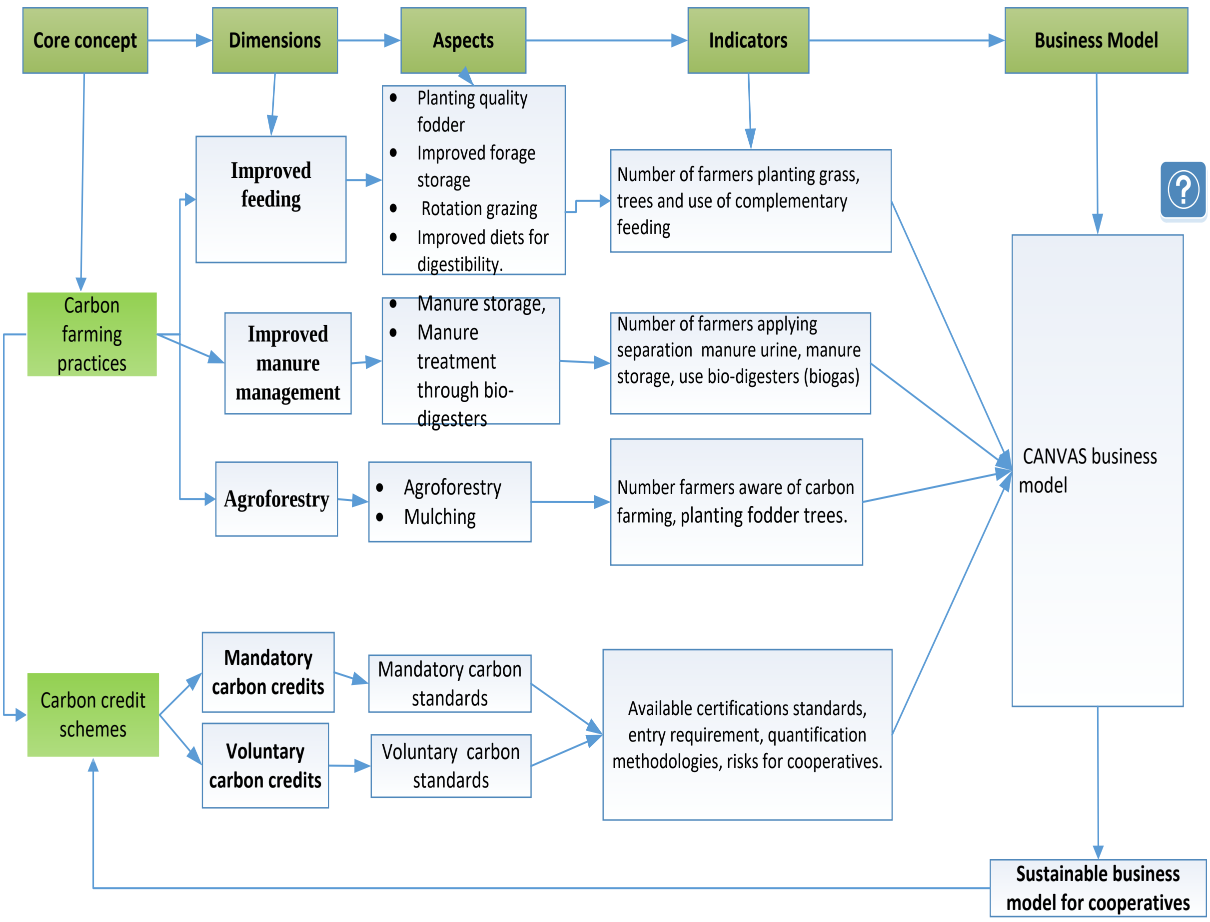
The Livelihoods Mount Elgon project adopted the Sustainable Agricultural Land Management (SALM) methodology (VCS VM0017) developed by Wold Bank carbon fund and Vi-agroforestry (Lee et al., 2015). Carbon credits methodology is based on the adoption of practices namely nutrient management such as mulching and composting, soil and water conservation such as retention ditches, agronomic practices such as crop rotation and intercropping, agroforestry (growing trees alongside crops and livestock), tillage and residue management such as zero-tillage, integrated livestock management with improved livestock feeding, breeding, and waste management, integrated pest management such as biological pest control (Nord, 2014). However, the literature could not detail on the SALM methodology CO_2 eq sequestration measurement. One of the experts interviewed, stated: "*SALM methodology is too technical because it requires lab soil analysis, on which smallholder farmers cannot do and is very costly that is why it failed*". The failure to quantify CO_2 eq sequestration, SALM methodology adopted the measurement of improved farmers' social and economic aspect such as women empowerment, food security, and farm revenues, increase in cow efficiency and crop productivity as a result of the adoption of SALM practices and this is monitored at the farmer level by filling in a simple monitoring form every season (Nord, 2014).

The project integrated carbon farming practices to improve biodiversity, soil fertility, and control soil erosion by controlling deforestation, watersheds management, improved agricultural practices, controlled grazing among farmers members. Secondly, the holistic approach of working with NGOs and private organizations to successfully link up the existing farmers' value chain to market opportunities which made the project successful. Besides, measuring project success through farmers' improved livelihoods where carbon finance comes as a bonus or extra income to their businesses.

2.6. Operationalization of study

The operationalization of the study was based on the recommendations of climate-smart agriculture and carbon farming practices related to livestock, such as improved feeding, manure management, and agroforestry (IPCC, 2015a) and (World Bank; CIAT., 2015). The listed practices aspects with specific indicators were analysed to prove their mitigation possibilities, benefits, and trade-offs. On the other hand, carbon credits schemes, entry requirements for smallholder cooperatives members in Kenya, quantification methodologies, and certification standards were assessed to draw up a business model as an illustration in the operational framework in figure 4.

Figure 4: Operational framework



Source: Author, 2020

CHAP 3. RESEARCH METHODOLOGY

This chapter indicates the description of the study area, research strategy, and methods, targeted population, methods of data collection, and tools. Besides, detailed procedures of data processing, analysis, and ethical consideration have been covered.

The study used both a qualitative and quantitative approach to data gathering and both primary and secondary data collection techniques. Primary data were collected between June 9th, 2020 to August 15th, 2020, in five different counties in Kenya.

3.1. Description of the study areas

Based on the Agriterra interest on carbon farming practices for extensive and intensive grazing management in Kenya, five cooperatives located in different counties were selected purposely taking into consideration counties with a high number of Agriterra clients cooperatives. The selected counties were: West Pokot, Uwasin Gishu, Baringo, Nyandarua, and Kiambu, as highlighted in figure 5 of the Kenya map.

Figure 5:Study areas (location of selected cooperatives in Kenya)

Source: Google maps 2020 ©

Climate description: The study areas comprised highlands and midlands rain zones of the Mount Elgon region such as Bungoma, West Pokot, and Uasin Gishu counties with a warm climate with temperatures ranging between 12^{0}C and 28.7^{0}C. Besides, Rift Valley regions such as Nyandarua and Kiambu counties with semi-arid ecological zones with warm weather and temperatures ranging between 12^{0}C and 18.7^{0}C (Muthoni et al, 2017).

3.2. Research strategy and methods

The study employed, desk study, survey, and key-informants interviews, as explained below:

Desk study: The research adopted the desk study to get familiar with the literature about carbon farming practices, credits benefits, and trade-offs. Furthermore, the desk study also clarified carbon credits schemes, GHG emissions quantification methodologies, certification standards, and procedures that have been presented in the findings.

The survey: A survey in which farmers and cooperative leaders were interviewed was carried out to know the level of carbon farming awareness and to capture a clear overview of real carbon farming practices being adopted among dairy cooperative member farmers in selected counties.

Key informant interviews: Besides, the study carried out interviews among key-informants involved in carbon farming practices or carbon credits trading in emerging economies to know the entry requirements for smallholder cooperatives members, risks, and differences in certification standards. The key informants were selected and interviewed to get the precise concept of carbon farming practices and carbon credits from both demand and supply perspectives, including intermediary partners. The snowball sampling was applied to find relevant key-informants for this study.

3.3. The population of the study and sample size.

Five Agriterra dairy cooperatives members from different counties in the rift valley and west part of Kenya were selected based on their grazing practices (extensive, semi-extensive grazing, or intensive grazing). One cooperative with fully extensive and one with an intensive farming system and three more with the semi-extensive farming system at distinct levels were selected. However, out of the seven, the cooperatives anticipated by the study, only 5 cooperated and participated in the survey. In each cooperative, four farmers and one cooperative leader were selected purposively. The study interviewed 16 key informants from carbon farming practices or carbon credits project stakeholders or working closely with farmers in emerging economies. A total of 41 sample size comprised of 25 farmers and cooperative survey's respondents and 16 key-informants' interviews (Table 1).

Table 1: Summary of the total sample size

			Survey respondents (Dairy Farmers)	
No	**County**	**Cooperative**	**Extensive or intensive grazing**	**No of respondents**
1	Uasin Gishu	Tarakwo	70% semi-extensive grazing	5
2	Kiambu	Kiambaa	100% intensive grazing	5
3	Baringo	BAMSCOS	70% semi-extensive grazing	5
4	West Pokot	Lelan	100% extensive grazing	5
5	Nyandarua	Olkalou	50% semi-extensive grazing	5
Total	**Survey**			**25 Respondents**
N0	**Key informants from Kenya**			**No of respondents**
1	Dairy expert			1
2	VI Agroforestry			1
3	Agriterra Business Advisers			2
4	CSDEK Researcher			1
5	KARLO			1
	Total			**6**
N0	**Key informants from the Netherlands**			**No of respondents**
1	ZLTO			1
2	Fair climate fund for Max Havelaar foundation			1
3	Climate-neutral group			1
4	HIVOS			1
5	Dutch farmers with carbon farming			2
	Total			6
N0	**Key informants from the USA**			**No of respondents**

1	VERRA	1
2	Winrock International	1
3	International Emissions Trading Association (IETA)	1
4	Allcot	1
	Total key-informants	16
	Total sample	**41**

Source: Author 2020

3.4. Methods of data collection and tools

The study was carried out during the times of COVID-19 pandemic where all sort of movements was restricted. An online questionnaire was designed and sent to the Agriterra team that was involved in the process of data collection, including the identification of respondents, sampling, translation, and interpretation of the questionnaire.

The study employed semi-structured questions (mix of closed or open questions) that were set for respondents' questionnaires to allow farmers to select one or more options on responses or provide their own opinions or answers. Besides, the researcher undertook online interviews with key-informants through Microsoft Teams, Skype, or Zoom, and key-informants interviews were recorded for academic analysis purposes.

Table 2: Summary of research methodology

SN	Research Question	Research Strategy	Tools for Data Collection	Indicators / Findings
1	*What are carbon farming practices linked to smallholder farmers in East Africa?*			
1.1	What are the existing carbon farming practices in East African cooperative members?	Quantitative and qualitative methods.	Survey, key-informants, and literature	Number of farmers aware of carbon farming practices and practising each carbon farming practice (improved feeding, manure storage, and agroforestry)
1.2	What are the financial and ecological benefits of carbon farming practices?	Qualitative methods	Key-informants and literature	Financial and ecological benefits
1.3	What are the possible trade-offs of carbon farming practices?	Qualitative methods	Key-informants and literature	Carbon farming practices trade-offs.
2	*What is the best way to integrate carbon credits programs with current agricultural cooperative business models?*			
2.1	What are the existing carbon credit schemes?	Qualitative methods	Key-informants and literature	List of carbon credits credit schemes.
2.2	What are the cooperative entry requirements for carbon credit schemes?	Qualitative methods	Key-informants and literature	Entry requirements in carbon credits standards in Kenya.

2.3	What accounting verifications, certification, and standards are used in the carbon credit schemes?	Qualitative methods	Key-informants and literature	Applicable carbon credits methodologies and certification standards in Kenya.
2.4	What are the risks associated with carbon credit schemes?	Qualitative methods	Key-informants and literature	Risks related to carbon credit schemes in Kenya.

Source: Author 2020

3.5. Data processing and analysis

The three dairy farming system clusters extensive grazing, semi-extensive grazing, and intensive were used to differentiate carbon farming practices adopted among cooperative members. Out of the 20 farmers, extensive grazing and semi-extensive grazing had eight individual farmers each and four farmers with intensive grazing.

The survey data were processed via Microsoft Excel spreadsheets, cleaned to produce descriptive statistics and further tabulation analysis. Information collected from the desk study, farmers' survey, and key-informants' interviews were triangulated and used in the discussion by comparing the specific variables to produce the report through the business model CANVAS.

3.6. Ethical considerations

During the data collection, analysis, and reporting processes, ethical considerations were respected. Introduction note on the farmers and cooperative leaders survey that shows the purpose of the study and requesting consent for survey respondents was used on each questionnaire. The researcher explained the study purpose and request consent for recording if necessary, during interviews, and the interviewees were given space to ask questions. Lastly, the information was used for the study purpose, and this report was written in neutral language that avoids individual names appearance.

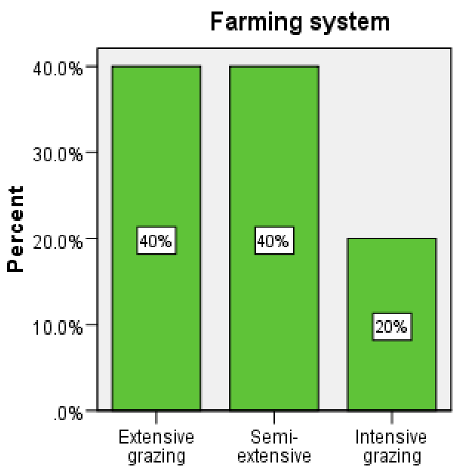
CHAPTER 4: RESEARCH FINDINGS AND DISCUSSION

In this chapter, findings from the desk study, survey, and key-informants interviews are presented and discussed.

4.1. The general presentations of survey results

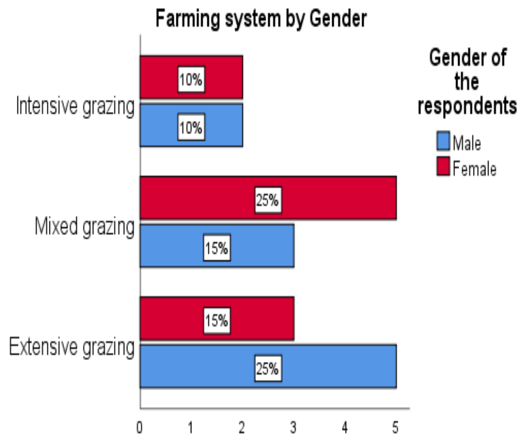
The findings showed that the respondents of the survey had an average of 7.5 years of membership in their cooperatives and 47 years was the average age of respondents' farmers. Individual farmers with extensive and semi-extensive grazing dairy farming systems were the majority, followed by intensive grazing by 40% and 20% respectively among participants farmers (figure 6). The survey results demonstrate that 52% of the respondents were males and figure 7 exposes that males were the most respondents in the extensive grazing system against semi-extensive grazing, where females responded most.

Figure 6: Dairy farming system



Source: Author 2020

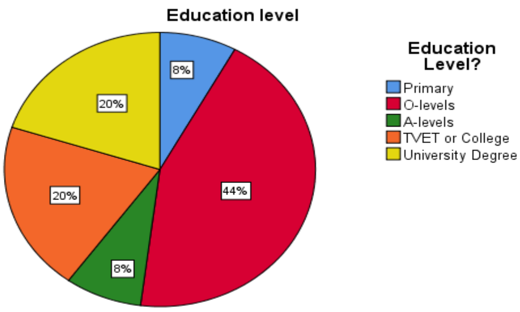
Figure 7: Farming system by gender of the respondents



Source: Author 2020

The education level of the respondents was assessed, and the results showed that 44% of the respondents did not complete O-level (figure 8). Outcomes demonstrate that farmers who did not complete primary school were all concentrated in the extensive grazing system.

Figure 8: Education level of the respondents



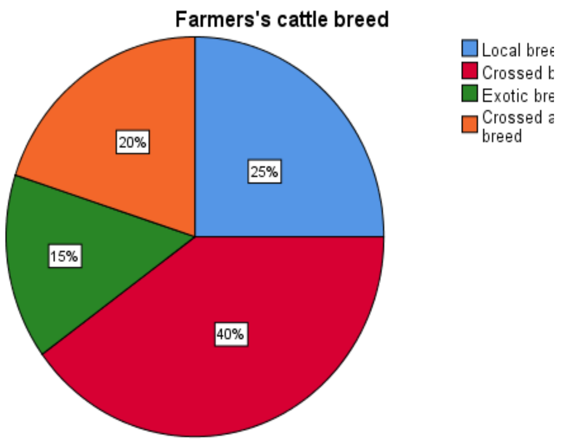
Source: Author 2020

Farmers were assessed on the level of mixed livestock and crops farming, and 100% of the farmers had a portion of cropland on their farms.

The results of the survey found that respondents had four milking cows on average. Also, the average production capacity of each of lactating cow was estimated at 10 litres of milk per day. However, the milk production varied among farming system whereby intensive grazing had the higher production of 14 litres per day per lactating cow, while the extensive grazing had 7 litres of milk per day per lactating cow. Besides, when asked about the milk market, 96% of respondents stated that their production was sold to the cooperative, whereas the remaining of the respondents sold their milk through middlemen.

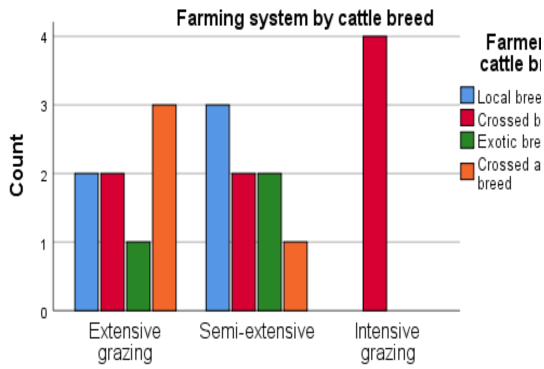
The results show that 40% of the respondent's cattle herds were crossed breeds followed by local breeds in figure 9. The results in figure 10 revealed that respondents with intensive grazing had only crossed cattle breeds. All respondents of the survey indicated that selling milk was their main revenue streams and 70% of respondents confirmed that selling crops or fodder was the extra source of income for their businesses.

Figure 8: Farmers' cattle breeds



Source: Author 2020

Figure 9: Farming system by cattle breeds



Source: Author 2020

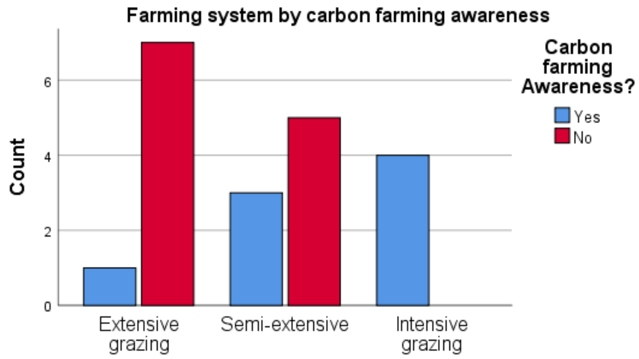
The land ownership among respondents was 90% owned with an average land size of 2 hectares per farmer except for four farmers who had a land size of 10 hectares on average.
Respondents with extensive grazing had 8 hectares against 1.6 hectares of land on average in the intensive grazing. 70% of the farmers selected hoe as the most used tool on their farm, and 90% of farmers confirmed that they ploughed their land for weed control.

4.2. Carbon farming awareness and practices.

The survey results show that 88% of the farmers were aware of climate change. Farmers and cooperative leaders confirmed the awareness of carbon farming by 52%. All respondents with intensive grazing were aware of carbon farming practices, while 90% of respondents with extensive grazing were not aware of carbon farming practices (Figure 11). 48% of the total respondents acknowledged having heard about carbon credits, and all respondents expressed an interest in joining carbon credits projects in case one would be developed within their farming practices.

The results revealed that 48% of the males were aware of carbon farming practices compared to 40% of the females. There was no apparent difference in carbon farming awareness and the education level, where 52% of each education level know carbon farming practices except for farmers who did not complete the primary school. The results stated that 100% of farmers who did not complete the primary school were not aware of carbon farming practices at all.

Figure 10: Carbon farming awareness by farming system

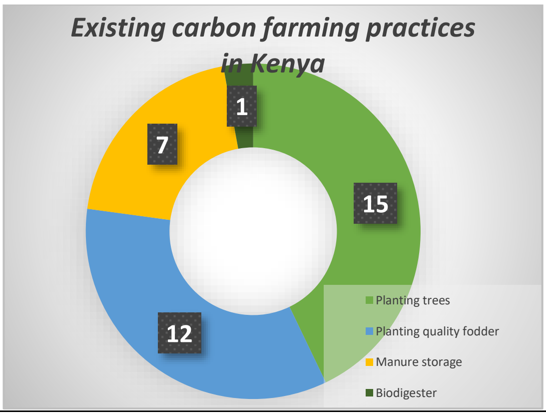
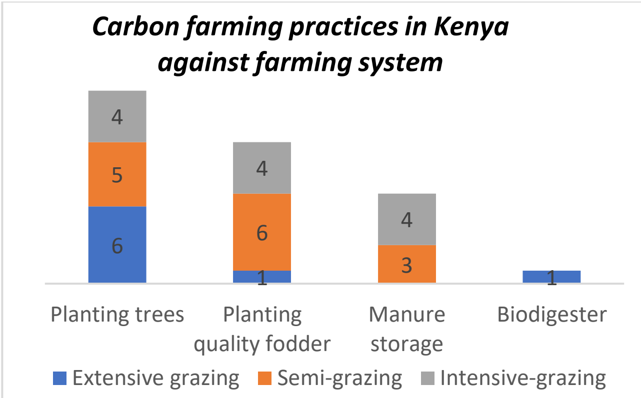


Source: Author 2020

One of the consultants in carbon farming practices in Kenya noted that "*carbon farming awareness level among farmers and the general population in Kenya is still low*". Also added that "*the government of Kenya is aware of the importance of carbon farming practices, but there is no active policy that encourages the practices or awareness to the general public*". The interview results highlighted that there, was not available research that highlight the carbon farming awareness levels in Kenya and calls for the Government of Kenya (GoK) and development agencies to take action to increase carbon farming awareness.

The findings showed that 88% of farmers were aware of climate change, and many of them pointed at the high frequency of drought and floods in their regions as the results of changing climate. The farmers and cooperative leaders confirmed to have heard about carbon farming and carbon credits at 52% and 48% respectively. In supporting the farmers' survey results, Chingala et al. (2017) stated that farmer's understanding and perception is the most crucial point to decide on which adaptation and mitigation practices to adopt and solve their social-economic and environmental vulnerabilities of the changing climate. Despite the high number of farmers who confirmed to have heard about carbon farming and carbon credits, 48% of the respondents indicated not knowing any carbon farming practices. The little awareness of carbon farming practices among farmers implies to the GoK and development organizations to invest in carbon farming practices awareness among dairy cooperatives members in Kenya, especially for farmers with extensive grazing where 90% were not aware of carbon farming practices. Despite the little awareness about carbon farming practices, the cooperative leaders' results highlighted that they have been sensitizing farmers to plant quality fodder and trees for them to increase milk productivity. Moreover, Agriterra should organize a general carbon farming awareness campaigns through production and dissemination of information using mass media communication such as radio, television, and newspaper advertisements to ensure a wide range of the population is coved.

For the existing carbon farming practices in Kenya, out of twenty respondents, categorised into three clusters where extensive and semi-extensive grazing system had eight respondents each and four for the intensive grazing system. The results of the farmers' survey exposed that farmers have been planting quality fodder, intercropping trees with their crops or livestock, manure storage and producing biogas through bio-digesters (figure 12). Farmers had more than one carbon farming practice on their land, and the practices varied per farming system. The results show that planting trees was the main carbon farming practice among farmers in extensive grazing farming systems, whereas growing quality fodder for improved feeding was highly practised among farmers in the semi-extensive grazing farming system. Farmers in the intensive grazing system had planting quality fodder, trees, and manure storage practices on their farms (figure 12). Besides, 100% of the respondents replied that manure produced in their farming goes back on their land. Surprisingly, only one respondent in the extensive grazing had biogas through bio-digesters (figure 13).

Figure 12: Existing carbon farming practices in Kenya.	**Figure 13: Carbon farming practices by the farming system in Kenya.**
	

Source: Author, 2020

A dairy carbon farming consultant in Kenya highlighted that improved feeding by growing better quality feed or forages such as Napier grass, Brachiaria grass, and Maize that can be produced in Kenya can be a good carbon farming practice. Besides, the use of crop residues such as rice mixed with organic industrial by-products that are applied in India can also be applicable in Kenya to reduce enteric fermentation emissions. Furthermore, practices of growing trees, practising crop rotation, and no-tillage on land can increase soil fertility, thus fixing nitrogen in the soil. One of the experts stated that the best way to reduced GHG emissions in dairy would be to reduce the number of dairy cows by keeping few with high production, hence reducing related feeding emission and preventing land structure degradation.

A consultant in carbon farming practices and climate change advisor in Kenya mentioned that manure management through adequate manure storage, covered manure storages, and proper application of manure to the field could reduce emissions in the air. In addition, the use of biodigester for biogas can reduce emission, and biogas cookstoves are rewarded as a tool to combat deforestation for firewood and clean energy for many offsetting project developers and increase farmers' profitability. However, the experts mentioned that some of the suggested plants might not grow in some regions because of the differences in ecological zones. Regions have different weather and soil types to extend that some fodder or trees cannot adapt in given weather or soil of that region, hence, suggested working with research organizations and feed breeders to advise of which appropriates practices.

The literature findings highlighted that improved feeding, such as planting quality fodder, rotation grazing, and use of supplement feeding, can serve as carbon farming practices (FAO, 2016). Also, practices related to covered manure storage or the use of manure to produce biogas have been practised as mitigation measures to NH_3 and N_2O emissions (De Vries et al., 2015). Furthermore, planting trees or fodder banks such as Calliandra, Sesbania sesban, Gliricidia sepium, Moringa oleifera and Cajanus cajan on the grazing land or cropland have been noted as carbon farming practice due to its benefits to soil fertility and improved biodiversity (Tennigkeit et al., 2013).

Farmers survey and experts interviews in the confirmation with literature highlighted that cultivating or intercropping quality fodder and trees with other crops or livestock have been in existence and practised by farmers in Kenya for decades (Hughes et al., 2020). Even though the term carbon farming seems new to some farmers, however, the survey results of farmers and cooperative leaders show that 100% of farmers have been practising one or more of planting trees, cultivating quality fodder, and manure storage practices. However, only 52% of farmers knew specific carbon farming practices on their farmers.

Planting quality fodder was not a common business among farmers with extensive grazing. Besides, the local breed was highly identified in the extensive grazing system, which might justify the low milk productivity documented among farmers with extensive grazing. It implies the need for chain actors to work in cooperation with feed breeders or research organizations to advise extensive grazing farmers on the appropriate quality feed to grow for the improved ecosystem and increased milk productivity. As also suggested by Ali et al. (2019), the use of by-products of sweet potato improves diet digestibility and hence, reducing cattle's N_20 and their CH_4 emissions per unit of digested feed.

Practices such as planting quality fodder, planting trees, and manure storage were highlighted among farmers with intensive grazing. Despite the manure storage among intensive grazing farmers, none of them was producing biogas. Thus, this highlights the missing opportunity of producing biogas through the stored manured on the farm that can improve their savings for time and money spent on firewood and electricity for lighting. Despite the high demand for biogas cookstoves by offsetting project developers, biogas production is criticized for requiring a heavy investment for installation where the cost was estimated at 70,000 Ksh to install a medium biodigester plus the intensive labour for manure handling for the biodigester.

The relevance of the highlighted carbon farming practices such as planting quality fodder (Napier grass, Brachiaria grass, and Maize), environmentally friendly trees (such as Calliandra, Sesbania sesban, Gliricidia sepium, Moringa oleifera, and Cajanus cajan) and manure storage or bio-digesters can be applied in the Kenyan context. Moreover, some of these trees and quality fodder species have been practised by farmers in Kenya, although their sustainability needs to be motivated through carbon farming practices benefits.

4.3. Carbon farming ecological and financial benefits.

The environmental experts 'interviewed, stated that planting quality fodder and trees help farmers to cover their land, which improves and enrich soil's nutrient fertility through organic material from grass or trees stems decomposition. Besides, grass or trees improves water bodies and water-holding capacity in the soil or rivers. Again, it was stated that planting trees, fodder banks, and practising mulching improves biodiversity conservation, control of pests, weeds, and diseases, facilitate pollination services. The interview results showed that planting trees can enhance the quality of soil maintenance and prevent soil erosion while maintaining carbon sequestration in the soil. Furthermore, planting fodder banks improves cattle digestibility where CH_4 intensity from enteric fermentation can be reduced and improving the soil fertility and fixing N_2O in the soil. The experts also stated that manure biogas production improves household health through reduced air and water pollution related to the use of manure and firewood, which in turn reduces respiratory illnesses/death and water-borne diseases.

In the confirmation of the literature, Le et al., (2012) stated that agroforestry alleviates environmental degradation by creating and enhancing carbon sinks and capturing carbon from the atmosphere to biomass and soil through photosynthesis. Also, planting trees and fodder can benefit the ecosystem and social-ecological outcomes, including flood risk management, water bank management, water cleaning, and adequate water resources management (Maynard, 2015). Also, the ecological benefits of manure management by using biodigester have proven the ability to reduce GHG emission through biogas production which serves as sustainable renewable energy by reducing the usage of fossil fuels or electricity (Xu et al., 2018).

Thorlakson & Neufeldt, (2012) stated that farmers who planted trees and cattle fodder in west Kenya had improved the crops and fodder productivity by decreasing soil erosion control and increasing soil fertility. Furthermore, the benefits of planting trees, fodder banks, and agroforestry in Kenya can be identified as the protection of soil from erosion, carbon sequestration, nutrient cycling, water conservation, and vegetation structure which provides benefits on wildlife habitat suitability (Le et al., 2012). As stated by key-informants, the use of manure management through biogas production improves household health through reduced air and water pollution related to the use of manure and firewood which in turn reduces respiratory illnesses/death and water-borne diseases. Despite, the prominent level of ecological benefits of the highlighted carbon farming practices, the main concerns for farmers are the financial benefits since it is their source of livelihood.

For the financial benefits of the carbon farming practices, the key-informants results mentioned that planting trees and fodder banks, farmers can increase crop and milk production or productivity hence increasing farmers' livelihood. Furthermore, the expert in renewable energy stated that the use of biogas cookstoves carbon farming, farmers can save costs spend on the usage of fossil fuels or electricity for cooking or lighting. Besides, the use of biogas cookstoves helps farmers to save time and the energy spend on cooking firewood collections while protecting the forest. In addition to the increase in yield, for each ton of carbon dioxide equivalent entered in the soil, is converted to carbon credit where a farmer can earn an extra income from carbon credits dividends.

Thorlakson & Neufeldt (2012) stated that farmers involvement in agroforestry provides substantial labour savings to women household members by reducing time spent on firewood collection where some women had reported walking over 20 km to purchase fuelwood in neighbouring districts in western Kenya. Also, women in low-tree-density areas reported being threatened by their neighbours in a struggle over firewood resources (Thorlakson & Neufeldt, 2012). Planting fodder legumes could be a useful source of organic matter that can improve soil fertility quality and crop productivity (Ojiem et al., 2014). Thus, the improvement of soil fertility could reduce the costs of alternative chemical fertilizer usage among farmers (Abdelraouf & Ragab, 2017). Furthermore, investing in biogas production, farmers can save financial costs that could have been spent on firewood or other sources of cooking energy. Besides, farmers would save time and avoid disputes related to firewood collection, and also farmers can supply slurry that can still be used as fertiliser in agriculture production (Gwavuya et al., 2012).

The stated carbon farming practices such as agroforestry in the form of intercropping grass or trees on their land have proven several financial and ecological benefits that can lead to higher crop yields and increased farmers' well-being in different forms in many parts of the tropics including Kenya. Thorlakson & Neufeldt (2012) found that 87.5% of farmers in western Kenya who had trees for four years, reported 3,250 Ksh income increases as benefits from the sale of fuelwood, timber, fruit, and seedlings. Also, Reppin et al. (2020) stated that planting trees species with higher economic value were widely spread across Kenya and plantations of fast-growing timber species are essential to achieve firewood self-sufficiency and to generate cash income. Besides, manure management through compost application on land has a positive impact on increasing soil organic matter and soil nutrients which increases crop or fodder productivity and could reduce farmers spending in chemical fertilizer (Rusinamhodzi et al., 2013). However, experts pointed out high labour intensive for manure storage and heavy investment to produce biogas production, which might not be efficient for smallholder farmers in Kenya.

4.4. Carbon farming practices trade-offs.

The experts in carbon farming practices pointed on the imbalances of economic and ecological benefits of carbon farming practices where the increase in environmental benefits increases farmers' investment. However, key-informants could not highlight more details on carbon farming trade-offs which is confirmed by (ICF International, 2013).

Table 3: Carbon farming trade-offs

Carbon farming practice	Benefits	Trade-offs
Plating quality fodder		One of the carbon projects consultants interviewed claimed that fodder production might increase the pollution swap from CH4 and N_2O to CO2 due to the use of heavy mechanical machines that use fossil fuels and chemical fertiliser intending to increase feed productivity.
Plating quality fodder through reduced tillage	Planting quality fodder by reduced tillage provides soil water available for the plants, which in turn stabilise soil health.	However, the core challenge under reduced tillage reduces yield in the short term and sometimes increases crop predators which imply many labours and chemical herbicide applications (Rosa-Schleich et al., 2019).
Agroforestry	Agroforestry systems contain high soil organic carbon, enhance soil fertility, nutrient content, and cycling, but also trees shelter the ground and thereby prevent soil erosion (Weston et al., 2015).	The key-informants results highlighted that land management through agroforestry was criticised of having a high emission non-permanence rate where carbon is sequestered through photosynthesis and released through respiration. Also, experts blamed the agroforestry for high pollution swapping where emission is sequestered but emission produced somewhere else.
Intercropping trees and crops or livestock		Agroforestry intercropping downsizes land size for grazing or main crop production, demands higher labour, and requires sophisticated management skills for farmers (Thorlakson & Neufeldt, 2012). Besides, agroforestry intercropping involves high costs to plant tree and maintenance through increased opportunity costs, in case of the agroforestry product does not end up attracting a market (Thorlakson & Neufeldt, 2012). In confirmation with key-informants, stated that intercropping fodder and trees involving too much monetary cost, time to grow nurseries, and downsizes grazing land or land for primary crop production.
Manure storage and use of bio-digesters	Manure storage reduces NH_3 and N_2O GHG Emissions (Hou et al., 2015).	Manure storage was criticised of requiring high labour intensive for farmers, which implies financial costs to install bio-digesters. Also, many studies have proved the effect of manure storages to be efficient in reducing NH_3 but increase N_2O and CH_4 emissions in the atmosphere (pollution swapping) (Hou et al., 2015)and (De Vries et al., 2015).

Source: Author 2020

In Kenya, several carbon farming practices such as planting quality feed, planting trees, and manure storage or biogas production have been developed and implemented successfully to address GHG emissions such as $NH_{3,}$ CH_4, N_2O, and CO_2 and increase farmers productivity. The experts in climate change mentioned that fodder production might increase the pollution swap from CH4 and N_2O to CO2 due to the use of heavy mechanical machines that use fossil fuels and chemical fertilizer intending to increase feed productivity. However, farmers' results have shown that the use of machines and the use of chemical fertilizers is very minimal due to the high cost. Also, 70% of the respondents mentioned hoe as a tool used in land preparation which is more environmentally friendly concerning soil tillage. Therefore, practices such as planting fodder can have minimal trade-offs in Kenya. Despite, the number of experts and technicians involved in carbon farming projects claimed that there is a lack of satisfactory scientific backup of the efficiency of carbon sequestration on non-permanence and pollution swapping.

4.5. Carbon credits schemes.

The key-informants results highlighted that there are several carbon credits schemes developed by the Kyoto protocol and Paris agreements operational in emerging economies as well as in developed countries. The schemes are in different forms, either mandatory or voluntary carbon credits systems. They added that in Kenya, only voluntary carbon credits schemes are operational due to the lack of legal policy support and financial compensation modalities of the compliance schemes. However, the expert could not provide further details except applauds the literature.
Malin et al., (2013) stated that carbon credits schemes operate in two approaches, carbon in setting or carbon offsetting; carbon in-setting is the approach of which many organizations apply to reduce their carbon footprint with their own or partners value chain. In contrast, the carbon offsetting refers to GHG reductions sequestered in one place that can be sold elsewhere for projects such as Agriculture, Forestry, and Other Land Use (OFALU), energy, methane capture, industrial gases, fuel switching (Malin et al., 2013). The unique common point for carbon offsetting and in setting refers to the reduction of GHG reductions (CAT, 2013). The concept of carbon credits was developed by the United Nations Framework Convention on Climate Change (UNFCCC) to stimulate climate change actions through its Kyoto protocol and Paris agreements (Ari, 2013). The protocols have set in place mandatory or compliance carbon market and voluntary market carbon credits schemes to encourage organizations or individual adoption of practices that can reduce GHG emissions (Perdan & Azapagic, 2011). Besides, Kenya has set National Appropriate Mitigation Actions (NAMAs) through the UNFCCC framework to share the responsibilities of reducing the burden of climate change (Linnér & Pahuja, 2012).

The GoK has drafted the NAMAs action plans at the national level and reported to the UNFCCC through the Intended Nationally Determined Contribution (INDC) commitment to addressing climate change domestically (Republic of Kenya, 2016). However, GoK did proceed to the next stage of action after the determination of NAMAs contribution commitment. As also stated by one of the experts, there is a high willingness to mitigate GHG emissions for the GoK. However, there is a lack of legal policy support and financial compensation modalities of the compliance schemes, which results in low adoption for NAMAs schemes. The implication of lack of legal policy support and monetary compensation modalities to smallholder farmers or local carbon initiatives makes it hard or even impossible for the application of mandatory or compliance carbon market which can reward carbon farming initiatives in the form of tax exemption or any other form of rewards.

However, Clean Development Mechanisms (CDM) which is flexible carbon trading schemes under mandatory market and voluntary carbon markets are actively operational in emerging economies including Kenya as stated by one of the key-informants interviewed in this study. In the Voluntary carbon credits schemes market, businesses, NGOs, governments, individuals, can voluntarily purchase GHG emissions reductions credits produced by projects within or outside the country. (Huang, 2013). Buying or selling of carbon can be traded through the CDM market or Over the Counter (OTC) where sales of credits are conducted directly, rather than through a formal trading platform for the voluntary market (Marketplace, 2012).

The applicability of both CDM and voluntary carbon credits schemes in Kenya has attracted carbon project developers since Kenya is still a niche sector for the carbon market.

4.6. Cooperatives' entry requirements in carbon credits schemes and project certification and procedures.

The researcher approached experts' Dutch farmers who participated in the existing carbon credits projects and project developers to confirm on the cooperative entry requirements. It was stated that cooperative members could not participate in credit schemes unless they have a carbon project. For cooperative members to participate in a carbon project, they must express the interest and have met project conditions such as land size or specific project's targets practices. One expert stated that organizing farmers into cooperatives is the initial stage and most hectic part of the project development. Carbon project developers and carbon credits traders noted that most standards have common procedures such as project design documentation, creating or use of existing a sort of cooperative of intended beneficiaries. Also, meeting with all facilitators and investors to determine the land size, carbon farming practices, and methodologies to register.
The literature revealed that, after the project design documentation (PDP) is done, the validation process starts by an independent approved auditor entity formally called Designated Operating Entity (DOE). Depending on the standards type, the project registration is done once the validation report has been approved. For the issuance of carbon credits, a monitoring document prepared by the project participants is verified subsequently by an independent entity before the issuance of carbon credits (Fairtrade International, 2015).

For the carbon projects to achieve credibility in registration, it needs to ensure and comply with the respective principles and criteria of the various standards schemes for the adoption of different certification procedures such as the involvement of accredited third-party auditors, the periodicity and minimum time intervals of verification, and culturally appropriate stakeholder consultations during the certification process (Merger et al., 2011).

As stated by carbon project developers and carbon credits traders interviewed, there is not a common procedure for project certification procedures. However, everything varies among projects and available budget investment. Besides, the cooperatives' entry requirement for carbon credits schemes varies by project methodologies and standards being used and carbon project targets. The entry requirement and project certification procedures serve as a competitive advantage for Agriterra which has existing organized client's cooperatives with necessary land size, existing carbon farming practices among farmers, and a set of organized stakeholder networks with a good relationship with the GoK.

4.7. Carbon credits standards.

The carbon market experts' results stated that CDM certification standard is widely used by carbon projects in emerging economies for compliance carbon markets. Besides, VERRA standards, Golden standards, and Plan Vivo standards are the leading voluntary carbon credits certification standards in emerging economies and Kenya explicitly taking into consideration the number of projects certified. Added, in recent years, AFOLU projects have shown a considerable market demand as a result of the individual or private organization interested to take climate action which has led VERRA to take over CDM standards for the last years. Experts from IETA and Allcot interviewed confirmed the decline in demand for DCM standards, which is alarming, and there is doubt of the future sustainability of the standards in Kenya. As stated by one of the experts from Vi-agroforestry "*the good news is that carbon credits standards can certify any methodology registered under another standard. E.g., the Golden standard can certify a project that is using SALM methodology registered under VERRA*".

The studies carried by Merger et al. (2011), a team of KIT (Arnoldus and Bymolt, 2015), VERRA website (VERRA, 2020) and (Marketplace, 2012) have highlighted several carbon credits certification standards that are widely adopted under compliance or mandatory and voluntary carbon credits schemes worldwide. However, some standards are too small in operation and specific in project coverage, and some of them are not operational in Kenya.

Malin et al., (2013) evaluated the total estimated cost of developing, verifying carbon projects among the leading standards such as CDM, VERRA, Gold standard, and Plan Vivo. The results demonstrated that DCM and VERRA were the most expensive at 500,000$, Gold standard at 325,000$ while Plan Vivo was the least at 267,500$. The results climaxed high value of the unit price of selling one carbon credit at Gold standards and Plan Vivo compared to the market price of CDM or VERRA carbon credits because they integrate producers' livelihood and carbon sequestration (Malin et al., 2013).

Several projects sell credits before they are produced or pre-paid other sell credits after quantification or post-paid and the payment modalities such as post-paid or pre-paid have an influence on carbon projects market price (Arnoldus & Bymolt, 2015). The choices for carbon credits standards among carbon project developers go along with the cost of certification and validation, and modality of payment either pre-paid or post-paid.

The modalities of credits trading have advantages and risks associated; the credits pre-paid offer a vast opportunity for project developers to pre-finance the project costs even though are criticised of fetching a lower price than those already issued as stated by carbon trading experts and (Arnoldus & Bymolt, 2015). In contrast, post-paid carbon credits attract a high price at the issuance. However, project developers face hardship to cover project development costs which can fail projects along with the implementation (Arnoldus & Bymolt, 2015). Besides, carbon markets experts criticised the high cost and prolonged process in project design involving too much paperwork which discourages project development. Also, low pricing or little dividends form of carbon credits in contrast to farmers' high expectations which can ruin projects scaleup.

The literature results also revealed that VERRA, Golden, and Plan Vivo standards are in huge competition for project development in emerging economies as stated by experts interviewed and confirmed by (Malin et al., 2013). Gold standards and Plan Vivo standards are more appropriates standards for carbon farming practices related to dairy in Kenya for their flexibility in adapting methodology. Also, Gold standards and Plan Vivo standards have high carbon credits price on the market due to the consideration of farmers' livelihood. However, project developers have the option of adopting methodologies and standards that supports their interest.

4.8. Carbon credits accounting methodologies.

The carbon market experts and literature pointed out several relevant accounting methodologies in Kenya related to AFOLU and glass land, livestock, and manure management are identified as highlighted in appendix 1. In Kenya specifically, Since cultivating fodder and planting trees involves land preparation, carbon farming experts stated that carbon farming aspects could consider the acceptable practices related to land management such as soil cover, no-tillage, protect soil erosion, and water banks. In the highlighted practices, SALM methodology registered as (VM0017) would be appropriate since it deals with adopting more sustainable land management practices (BioCarbon Fund, 2011). However, the SALM was criticized for being too technical and costly for smallholder farmers which requires lab soil sampling and analysis as stated by one of the experts.

The is a specific relevant methodology related to cultivating feed and planting trees as quality feed registered as VM0041 which estimate CH_4 emission reductions generated by using improved quality feed into ruminants' diet (Zoupanidou, 2019).

Another carbon farming aspect related to cultivating feed and planting trees, the consideration of grass cutting stages, and grass cutting frequency which determine the feed and soil quality can be noted as stated by one of the carbon credits experts. The methodology aspect would measure the nitrogen fixations rate reduction in the soil where (VM0022 methodology) would be relevant (Michigan State University, 2013).

For farmers with extensive grazing systems, there several methodologies available such as sustainable grassland management (VM0026) which consist of improving the rotation of grazing animals, limiting the grazing of animals on degraded pastures, and restoration of severely degraded lands in semi-arid regions (FAO, 2014).

Besides, the VM0021 methodology which considers the Agricultural Land Management (ALM) practices, such as grassland and rangeland restorations, reductions in soil erosion, and productivity of grassland and savanna plant communities would be relevant for soil carbon quantification (The Earth Partners, 2012).

The AMS-III.Y and VMR0003 methodologies quantify methane avoidance through the separation of solids from wastewater or manure treatment systems (NativeEnergy, 2012). Carbon market consultants mentioned once again that manure management through efficient manure storage in zero-grazing units, composting, use of bio-digesters, and proper manure application as carbon farming practices for farmers with intensive grazing. Therefore, AMS-III.Y and VMR0003 methodologies are relevant to manure management practices.

Based on the controversial criticisms on carbon sequestration quantification or accuracy in measuring emission additionalities, several methodologies have simplified emission quantification by measuring producer's livelihood through the respect for human rights, gender equality; protection of the environment, and sustainable and equitable trading along the product value chain (Fairtrade International, 2015). However, GHG emission methodologies are criticised of being fragmented, non-uniform certification, verification and registration procedures, little monitoring, and regulation mechanisms cause the lack of trust in the market. For Agriterra, there are possibilities of developing crosscutting carbon projects in the dairy sector by incorporating practices such as soil management, cattle feeding improvement which increases productivity, and the use of the improved source of energy through cooking stoves, biodigesters. Consequently, the integration of crosscutting carbon farming practices would increase environmental sustainability and farmers' livelihood for any farming systems, either Intensive, semi-extensive grazing, or extensive grazing.

4.9. Risks associated with carbon credits trading.

The results from carbon markers experts mentioned that farmers have high expectations for the carbon credits benefits, once carbon projects fail to integrate carbon sequestration and farmers' livelihood which can discourage farmers, and the project scales up.

The experts stated that land size is the leading factor for AFOLU and livestock carbon-related projects. The challenges of smallholder farmers' land size require project developers to increase the number of participants which increases project operation cost in terms of sensitisation, monitoring, validation, and verification. In addition, the changes in the lack of land ownership affect farmers in decision making to invest in long-time carbon farming practices and discourage carbon credits project developers' investment.

Experts in carbon markets and climate change advisors confirmed with the literature such as (Perdan & Azapagic, 2011), have criticised voluntary carbon markets prices fluctuation over time as a result of the performance of the global and international markets economy which can breach contracts of carbon producers and buyers.

In Kenya, the voluntary market was presented as the most leading carbon credits schemes; although, it was said to be exposed to risks such as fake carbon credits, falsifying carbon monitoring records, and fake offset schemes. Besides, high pressure on local people and fraud risk through low incentive structure were reported for voluntary carbon markets (Martin & Walters, 2013). Similarly, high corruption and lobbying were reported for powerful participating companies in the distortion of carbon market prices (Martin & Walters, 2013).

Market fragmentation, insufficient information due to lack of regulation and monitoring mechanisms, and non-uniform certification, verification, and registration procedures were the additional risks with voluntary carbon markets (Ari, 2013). The lack of policy framework support or legal enforcement among the project stakeholders can influence any of the project actors to withdraw along with the project implementation, hence, leading to project failure. Despite the risk associated with the voluntary carbon market, it was presented of having more advantages such as lower transaction costs, less bureaucratic procedure, creativity, and innovation for projects and there is no need for start-up capital to prepare the offsetting projects (Ari, 2013).

Carbon farming practices such as improved land-use, including reforestation and manure management, plays a particularly significant role in many countries' emissions mitigation measures. However, how carbon farming is understood, valued, and interpreted by actors responsible for implementing carbon credits projects is still unclear and sometimes taken as a non-concrete commodity (Twyman et al., 2015).

Summary of chapter 4: The study findings have highlighted that dairy cooperatives members have been practising carbon farming practices such as planting quality fodder, planting trees, storing manure on the farm, and using biodigester to produce biogas. However, few farmers new the term carbon farming, which gives a call to Agriterra to raise awareness among farmers and stimulate carbon farming sustainability and benefits to farmers. The study identified that the need for applying carbon farming practices vary per farming system where planting quality fodder was the primary need for every farming system to increase farmers yield. Also, planting trees would be more appropriate to farmers with extensive grazing while the use of biodigesters would be more appropriate to farmers in semi-extensive and intensive grazing. The most incredible trade-off is the imbalance of ecological and financial benefits to farmers. Carbon credits schemes are operational in Kenya lead by voluntary carbon markets. The golden standard was identified as the most appropriate carbon credits standard in dairy projects because it has a high carbon credits price on the market due to the consideration of farmers' livelihood. Therefore, it is an excellent opportunity for Agriterra to join the race of developing carbon projects to invest in the client's cooperatives carbon farming practices. For Agriterra to have successful carbon projects, it should invest in advocacy for carbon farming awareness among smallholder farmers in Kenya. Furthermore, it was advised for Kenyan governments to improve on land ownership management systems which can empower farmers decision making on their land.

CHAPTER 5: CARBON FARMING AND CARBON CREDITS BUSINESS MODEL FOR DAIRY COOPERATIVE MEMBERS.

The analysis of the findings was used to decide on carbon farming and carbon credits viable business models. The CANVAS template triple layers analysis was used to demonstrate cooperatives farmers' existing business model to identify how Agriterras' business model can improve cooperatives clients value proposition and impact on social, financial & environmental aspect through carbon farming practices.

5.1. Existing CANVAS business model for dairy cooperative

This CANVAS business model was adopted to provide a set of a generic description of how a firm organises it selves to create and distribute value in a profitable manner (Baden-Fuller & Morgan, 2010). In the context of this study, the CANVAS business model template highlighted the common key points from surveyed cooperatives such as key partners, key activities and resources, value proposition, customer relationship and channels, customer segment, cost, and revenue streams. In addition to the social, financial & environmental cost benefits (table 4). This CANVAS model template provides the common and existing cooperatives businesses as results of the farmers and cooperative leaders survey.

Table 4: Business model CANVAS of dairy cooperatives.

Key partners 1. Farmers 2. GoK 3. Agriterra, 4. Brookside, 5. New KCC 6. Banks & SACCOs, 7. KDB, 8. KBS 9. Fairtrade 10. KALRO 11. Unga Group 12. Input providers	**Key activities** 1. Milk collections, bulking & processing. 2. Provision of inputs to farms. **Key resources** 1. Management, 2. Trust with farmers, 3. Network with buyers.	**Value proposition** 1. Negotiate markets for farmers 2. Milk value addition 3. Lower loans for farmers.	**Customer relationships** 1. Information, 2. Low price from processors. **Channels** 1. Milk collection outlets	**Customer segments** 1. Brookside 2. New KCC
Cost structure 1. Management costs **2.** High cost of transportations		**Main revenue streams** 1. Milk selling (**27-38 Ksh/L**) 2. Crops or feed selling		
Social & environmental cost **1.** Harmful GHG emissions 2. Loss of soil life and erosion **3.** Loss of biodiversity		**Financial & environmental benefits**		

Source: Author, 2020

Relying on farmers and cooperative leaders survey results highlighted a list of their key-partners and partners ranging from input providers and supporters along their value chain. Unga group was identified as one of the vital input providers while SACCOs, Cooperative bank, Transnational bank was listed as the financial supporters to cooperative farmers. Kenya Agricultural and Livestock Research Organisation (KALRO), Kenya Bureau of Standards (KEBS), Kenya Dairy Board (KDB), Fairtrade, and Agriterra were mentioned as their key partners in a range of activities such as chain coordination, capacity building, and research and product certifications. Brookside and New KCC milk processors were highlighted by the survey results as the farmer's cooperatives markets segment for their milk.

The study results highlighted the farmer's cooperatives activities such as milk collections from farmers, milk bulking, cooling & processing, and further selling to Brookside and New KCC milk processors. Besides, farmers cooperatives were providing inputs to farmers. Again, the survey results highlighted that farmers cooperatives have been sensitizing farmers to plant quality fodder and trees for them to increase milk productivity which is carbon farming practices.

The results mentioned the generic value proposition to cooperatives, such as market negotiation and lower loans for farmers, stimulating quality milk. Despite, the sensitization for farmers to plant quality fodder and trees for them to increase milk productivity, carbon farming is not part of the cooperative value proposition due to little awareness and not linked to carbon markets.

For the analysis of cost streams and revenue streams, two scenarios were highlighted for intensive and extensive grazing farming systems, based on the farmers and cooperative leaders' responses. The study considered cost and revenues responses for Lelan cooperative taken as an extensive farming system while Kiambaa was taken as an intensive farming system.

Milk revenue: The survey results highlighted that 7 litres of fresh milk were the general average of milk production per lactating cow per day for the Lelan cooperative and 14 litres for the Kiambaa cooperative. Also, 70% of the farmers indicated that their milking days were ten months per year meaning that were milking 300 days per year, and one litter of milk was being sold at 27 Ksh at the farm gate for Lelan cooperative and 38 Ksh for Kiambaa cooperative. Milk output was calculated per year, keeping other factors constants. However, the information related to dry cows and calving interval was not considered in the calculation below, only production of milk for one lactating cow for a period of 300 days of lactation was calculated.

Table 5: Farmers milk output for one dairy cow

Items	**Lelan**		**Kiambaa**	
	Per day	**Par 300 days**	**Per day**	**Par 300 days**
Milk production per lactating cow per day	7	300*7=2,100	14	300*14=4,200
Price of litre of milk at the farm gate	27		38	
Milk output	**27*7=189**	**2,100 *27=56,700**	**38*14= 532**	**4,200 *38=159,600**

Source: Author, 2020

Milk revenue per lactating cow per day= [Milk price (Ksh per Litre) X Milk volume (kg) per day]

Milk output per lactating cow per year= [Milk price (Ksh per Litre) X Milk volume (kg) per year] X 300 days

Milk output at Lelan = [27 Ksh X 2100kg] =56,700 Ksh per 300 days

Milk output at Kiambaa = [38 Ksh X 4,200kg] =159,600 Ksh per 300 days

Cost streams: The cost prices were calculated by summing up the total variable cost for one cow per year. However, some costs streams such as the cost of concentrate was estimated for 300 days of lactation.

Only variable costs contributing to the milk production were considered, such as the cost of feeds and concentrates, veterinary drugs for disease control were estimated in addition to the family labour. The estimated cost was calculated based on survey results, as stated by the cooperative leaders interviewed.

The opportunity cost of family labour was estimated per year at 30,000 Ksh for Lelan and 60,000 Ksh at Kiambaa cooperatives for a farmer with ten cattle on the average. In this case, the share value of one cow was calculated by taking the total cost of labour over/number cows.

The average cost of feed produced at the farm and off-farm, including roughages and compound feed, was estimated. For farmers in intensive grazing, mentioned that they do make 80% of the feed themselves; thus, the calculation considered 20% of the yearly estimated cost of feed per 1 cow per year at Kiambaa.

For Lelan cooperative, the average cost of feed concentrates estimated half of the price since it was noticed that farmers do feed concentrates once in two days for the period of 300 days of lactation. Other costs estimates including electricity, fuel, and water for farmers with those facilities.

Table 6: Variable cost per year for one milking cow

Items	Lelan	Kiambaa
Medication	5,040	6,000
Concentrates	5,400	21,600
Feeds cost	18,000	38,400
Labour	3,000	6,000
Other Cost	960	7,200
Total variable cost	**32,400**	**79,200**

Source: Author, 2020

Gross margin = [Milk price (Ksh per Litre) X Milk volume (kg)] - Variable costs

Gross margin at Lelan = [27 Ksh X 2100kg] =56,700 Ksh – 32,400 Ksh = **24,300 Ksh**

Gross margin at Kiambaa = [38 Ksh X 4,200kg] =159,600 Ksh – 79,200 Ksh = 80,400 Ksh

The farmers 'gross margin at Lelan was computed at 24,300 Ksh for producing 2,100 litres of milk for 300 days of lactation while at Kiambaa was estimated at 80,400 Ksh for producing 4,200 litres of milk.

Cost price: Total variable costs/Total milk volume

Cost price at Lelan: 32,400 Ksh/2,100 kg= 15Ksh
Cost price at Kiambaa: 79,200 Ksh /4,200kg = 19Ksh

The results show that it cost 15Ksh and 19Ksh to produce 1 litre of milk at Lelan and Kiambaa cooperatives, respectively. Farmer's gross margin implies that by selling 1 litre of milk at 27 Ksh at Lelan, a farmer gains only 12Ksh or 44.4% of the price share while at Kiambaa, a farmer gains 50% of the price share by selling 1 litre of milk at 38 Ksh.

The survey results and experts interviewed stated that cooperatives are facing significant challenges of poor road infrastructures to outsource milk from farmers or to access the market. Consequently, farmers make a considerable loss of milk due to inferior quality compliance and the unstable market because of poor road infrastructures, low information flow along the milk chain, which increases farmers' cost of production. The uncertainty of the milk market put farmers in a weak position to negotiate the price for their produce, resulting in low pricing for farmers.

Cost benefits analysis gives a message on how the cost of production is still a challenge for farmers. Kenya's government and partners have invested much effort to improve farmers' output and reduce related costs. However, multi-stakeholder' efforts and interventions are needed to increase farmers' share value by lowering the cost of production.

The intensive farming system business model looks quite beneficial for farmers because of high productivity compared to extensive farming produced 14 against 7 litres of milk production per day. Low milk production below the regional potential was attributed to inferior breed in most extensive grazing and inadequate feeding systems for both systems. In addition, the high variable cost documented was attributed to economies of scale where fixed cost never change when farmers have few cows.

5.2. Agriterra business model to support dairy cooperatives carbon farming and carbon credits

Agriterra is an international organization with a vast experience of working with farmer organisations in emerging economies by providing them advisory services to improve business performance. Agriterra work through a holistic approach of:

a. Business development for client's cooperatives
b. Improved client's cooperatives service provision and
c. Lobbying and advancing for the policy changes.

Vi-agroforestry as the implementing agency of the Livelihood Mount Elgon project has a lot in common with Agriterra both as international organizations, such as extensive experience in emerging economies and common business models to improve farmers organizations businesses. However, Vi-agroforestry organization have shown the impact of its influence on the improved ecosystem and client's farmers organization value proposition through carbon farming practices as we learned from Livelihoods Mount Elgon project. The project improved the livelihoods of 30,000 smallholder farmers by creating 2 billion Kenyan Shillings value in the dairy sector over a period of 10 years and sequester more than 1 million ton of CO_2 equivalent and create tangible environmental benefits for water and biodiversity (Livelihoods Funds & VI Agroforestry, 2016).

Livelihoods Mount Elgon project increased milk productivity from 3 litres of milk per day to 6 - 9 litres per day per cow using improved fodder crops, introducing improved breeds for high-quality artificial insemination. Brookside dairy Ltd insured farmers milk market for a period of 10 years (Livelihoods Funds & VI Agroforestry, 2016).

The success of the Livelihoods Mount Elgon project was based on VI Agroforestry's unique business model of working with multiple stakeholders such as carbon project developers, the private sector, and NGOs. VI Agroforestry's working model has shown a robust viability business model of integrating carbon farming practices among smallholder farmers into credits schemes. Besides, the project has demonstrated the potential of reducing GHG emissions and improve agricultural productivity with minimum financial investment for farmers cooperatives.

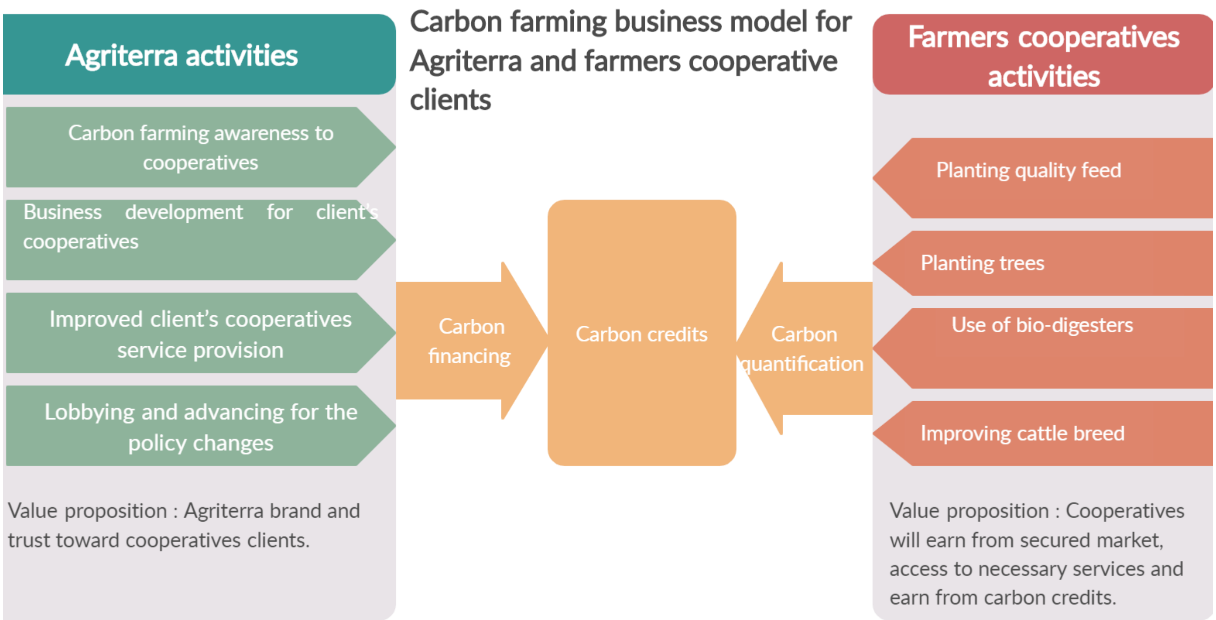
Therefore, the extensive experience of working with farmers cooperatives gives Agriterra a potential niche market to influence on farmers carbon farming practices to make farmers cooperatives bankable through carbon farming benefits. Furthermore, the integration of carbon farming credits into Agriterra and farmers cooperatives business model would bring win-win benefits for both parts.

5.3. Proposed CANVAS business model

The analysis of Agriterra, Livelihoods Mount Elgon project and farmers cooperatives business models have resulted in the identification of opportunities to promote carbon farming and carbon credits into dairy farmers cooperatives business models in Kenya.

Agriterra is well-positioned to promote farmers carbon farming practices among its dairy clients, having a local presence and a sound knowledge of cooperatives and dairy farming. In addition, Agriterra is working with well-organized farmers cooperatives that have enough land size and already existing carbon farming practices that can be registered in the carbon project despite little awareness. Agriterra can support cooperatives to highlight the value proposition of carbon farming and carbon credits given the extensive experience of lobbying and advocacy for policy change and raising funds that can finance carbon farming and carbon credits projects among dairy cooperatives clients. The possibilities of integrating carbon credits business into both Agriterra and farmers cooperatives businesses would require the number of activities for both parts (figure 14).

Figure 11: Carbon credits working model of dairy cooperatives supported by Agriterra.



Source: Author, 2020

As we learn from Livelihoods Mount Elgon project, the success of carbon farming interventions among smallholders' farmers through the improvement of feeding system and biogas production, would require a multi stakeholder's involvement with common objectives of improving the ecosystem and farmers' livelihood.

Agriterra can design multi stakeholder's involvement using triple helix model where research institutions, private sector and market supports can work together to ensure farmers improved livelihood and ecosystem through carbon farming practices. Research institutions such as KALRO and universities can be involved to advise farmers on the appropriate and cost-efficient carbon farming practices such as types of feeds, use of bio-digester, etc.…).

The role of market supporters, such as public organizations and donor agencies, should be considered to develop supportive policies and projects development finances. In addition, the private sector such as lead milk processors, banks, private international organizations should not be left behind for their role to ensure stable markets and contribute to carbon farming finance through corporate social responsibilities for carbon farming scale up.

What would be the value addition of the existing business model for both Agriterra and farmers cooperatives in case carbon farming practices are successfully implemented. CIAT, (2012) stressed sustainable markets for smallholders' farmers as a way of alleviating poverty and ensure continuous business for their production.

The farmers and cooperative leaders' surveys result highlighted that farmers and cooperatives are negatively affected by low productivity due to poor feeding, poor pricing due to unstable market and high variable cost of production due to economies of scale. Therefore, carbon farming interventions through biodigesters, planting quality fodders, and trees to improve cattle feeding systems can reduce the right proportion of GHG emissions in dairy. Besides, would improve ecosystem services such as biomass production, improve soil formation and retention, water cycling, and sequestrating GHG Emission. Similarly, the practices can improve cattle feeding system, which can increase milk production, improve milk cost benefits, and ensure farmers a stable market where farmers cooperatives can earn from carbon credits business as additional income. The success in stakeholder engagement will link the information channels, which leads to the need for quality compliance and ensure a sustainable market, hence reducing milk losses.

Once stakeholder's engagement is ensured for carbon farming projects among farmers cooperatives in Kenya, Agriterra will benefits in the increase of the market brand, gain higher credits with the farmers' cooperatives trust. The new business model will increase the cooperatives value proposition and revenue streams from carbon credits while Agriterra will strengthen its brand name and trust with clients cooperatives. Furthermore, the new business model will reduce farmers GHG emissions and make their farmers more resilient to climate change. Figure 19 highlight the summary of proposed new CANVAS business model for both Agriterra and farmers cooperatives once carbon credits project is implemented.

Table 7:Carbon credits proposed CANVAS business model for Agriterra and cooperatives

Key partners	Key activities	Value proposition	Customer relationships	Customer segments
1. Market supporters 2. Private sector 3. Research institutes	1. Carbon farming practices 2. Business development 3. Lobbying for carbon financing and policy change	1. Access on carbon credits dividends 2. Stable markets for farmers	**1.** Loyalty Commitment	1. Corporate social responsibilities 2. Voluntary markets
	Key resources		**Channels**	
Cost structure		**Main revenue streams**		
1. Carbon project investment		1. Increased productivity/ animal/ lower production cost of milk 2. Additional income from carbon farming products 3. Better prices per litre of milk 4. Carbon credits dividends		
Social & environmental cost		**Financial & environmental benefits**		

1. Good reputation for efficient milk production for people, planet, and profit.
2. Increased productivity through circular agriculture and carbon farming.
3. Additional income from carbon credits (bonus)

Source: Author 2020

5.4. Limitations of the study

This research comprehended some limitations. The sample size proposed for this research was adjusted due to the COVID-19 restrictions of movement and low network covered in Kenya hindered the researcher from covering all intended sample and study areas. Therefore, the researcher might have missed crucial information on carbon farming practices in Kenya. Also, the sample size was very small to conclude that the study findings reflect the real realities of farmers' carbon farming practices in Kenya.

The validity of the data: By carrying out the online surveys, many realities must have missed out due to the lack of observations part of the research methods. Again, the lack of knowledge on the social context realities of the respondents might influence the misinterpretations of the findings. Besides, there was a long process of an online questionnaire and data collected through business advisors using phone calls and translation from English, through Swahili to other local languages; questions might have been asked in different forms might influence the result not to reflex the real reality on the field.

The reliability of data*:* The study intended to survey farmers who participated in carbon farming projects in Kenya to learn from their experiences, but they could not be reached because of COVID-19 pandemic lockdown and poor network coverage in the region. Therefore, the researcher adjusted the sample by interviewing two Dutch farmers as key-informants who participated in carbon farming projects, even though the context was different, but practices were similar.

The researcher trained business advisors on the questionnaire; the questionnaire was tested, piloted, and the survey results were validated with research assistants before the analysis. Furthermore, there was no researcher influence, conflict of interest, or bias on the study findings since the respondents and key-informants did not know the researcher physically. Besides, the reliability of the data was further improved by using three methods, such as key-informant interviews, farmer surveys, and desk study, to enrich the analysis of the findings. The reliability and relevance of the results can be trusted due to the similarities with the existing literature reviews.

5.5. Role as a Researcher

Introduction*:* This research aimed to advise the commissioner Agriterra on the potential carbon farming practices among dairy cooperatives members and assess the viability of linking such practises to carbon credits schemes and assess if this could offer a viable business model in Kenya

Reflecting on the topic: The topic of was taken from Agriterra vacancy for internship research of a feasibility study on *carbon farming and carbon credits: a viable business model for agricultural cooperatives in emerging economies* under its project number (20at-8613) in March 2020. My motivation to apply for this call was based on three reasons; first, I wanted to get a commissioner for my research thesis; secondly, I wanted to get hands-on experience by working with experts from a Dutch International organization operating in more than twenty countries worldwide working for farmers cooperatives. Finally, I got attracted by the terms *carbon farming and carbon credits* which were new in my ears, after reading the meaning I realized that they were related to climate-smart agriculture which was my area of interest. After being selected in the project by Agriterra, I proposed the topic to VHL University, and subsequently, I was given the green light for my thesis.
Throughout the meeting with both VHL University and Agriterra supervisors, we agreed to narrow the research topic to sustainable carbon farming and carbon credits business models for smallholder dairy

cooperatives in emerging economies; a case of Kenya. The formulation of the topic helped me to formulate the study objective based on the project research questions (main and sub-questions) that servers both purposes (thesis and Agriterra report). As a researcher, setting up research objectives and questions boosted my confidence for it and gave me a hint on how I should design methodology.

***Reflecting on research methodologies and data collection**:* Getting a precise research topic was a good start even though I was going to carry out my research during the COVID-19 pandemic; I started worrying about the methodologies to be adopted. Reflecting on my mini-thesis and action research in practice reports, I realized that it was good preparation for my thesis work in which happened in the same context and situation during the COVID-19 pandemic.

I adopted desk study, online farmers survey, and interviews for key-informants methodologies given the COVID-19 regulations such as social distancing, restricted movement, and prohibited group gathering. Carrying out desk study was a precondition for me to have a clear understanding of the topic and to answer some of my research questions. Getting the specific literature on my topic was the trickiest part of my study. However, it was a good -learning experience that enriched my future research career to learn how to combine different resources and references. Carry out interviews for key-informants through Microsoft teams, Zoom, or Tweeter was a pleasant experience to learn how to invite an interviewee, arrange the meeting, and manage time during the interview. One most meaningful experience was to ask probing questions; I found it challenging initially, as it was difficult to fully keep informants to focus on the subject/topic with the probing questions. I had to adjust fast because it required me to know what I was looking out of the interviews. With the experiences of carrying online interviews, I now feel confident to do professional interviewing in my future research endeavours.

Besides, I thought that designing the online survey would be quite easy and simple for respondents to reply in less than one day, but I realized that it was complicated more than I anticipated. It was a very tiresome process to involve many research assistants and the Agriterra team in Kenya, sending reminders messages on WhatsApp or emails and explaining the meaning of each question for proper translation. Finally, out of seven targeted cooperatives, only five cooperatives responded for the survey, and it took more than one month to get five responses for the five Agriterra cooperatives.

Reflecting on Data processing, Analysis, and report writing:

Data processing and analysis would not have been easy if it were not to apply the skills and experience, I learned from action research in practice. During the interviews, I realized how difficult it was to type the interview while keeping focused to ask questions or remember every single word for transcription after the interview. Waa! I remembered that recording the whole interview was much easier to transcribe during action research in practice. Yes, I started recording the interviews after getting consent, which made life easy because recording gave me the option to transcribe or hear the message in each recording and relate it to research questions. I learned that qualitative data presentation and analysis were much complicated and time-consuming, especially when you mix up the raw materials.

The survey data were extracted in Excel format and cleaned. Data cleaning was the most challenging step of this research because I realized that farmers had skipped many questions and some responses were not relevant, which pushed to call back on the field to confirm. Initially, I thought that using the SPSS in the analysis would be an added value to my research, I took good time making SPSS syntaxes, but I realized that was not necessary because there was no hypothetical research question adding that sample was too small.

Making mistakes over mistakes or learning the hard way! Sending the first thesis draft to my supervisor was full of grammar mistakes and poor referencing because I was not taking attention to grammar errors. What feedback from my supervisor! I felt ashamed, and I decided to be proofreading any work that I must send to avoid the same shame I felt. "*Challenges make you discover things about yourself that you never really know*" Cicely Tyson. However, I learned that the quality of my professional writing needs to be improved to a higher level.

I learned that analysis and report writing was a pleasant experience to mix findings collected throughout literature, survey, and interview to make a conclusion on the business viability of carbon farming and carbon credits for cooperatives in emerging economies.

What can I say, lessons learned in this thesis and action research in practice helped to improve my overall research and writing skills? Lessons such as working on a project that feeds more than one purpose, organizing online meetings, how to ask probing questions, requesting a consent in case I wanted to record the session. Also, reading and writing critically and professionally and proper referencing academically.

Conclusion: This thesis trajectory was helpful to me not only for academic purpose but also, I realized opportunities for the future career of developing carbon markets projects in emerging economies. I am confident that any lesson learned will help me to act differently and better in the future for similar exercises. "*The only impossible journey is the one you never begin*" Tony Robbins.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

This chapter provides a conclusion and recommendations based on the results of the research in a way to address the objective and answer the questions set out in the introduction part of this thesis report.

6.1. Conclusion

Carbon farming practices in Kenya: Farming practices planting quality fodder, intercropping trees with their crops or livestock land, manure storage and producing biogas through bio-digesters have been practised among dairy cooperatives farmers in Kenya and were backed by sciences to be the potential dairy carbon farming practices in dairy. Planting trees was the primary carbon farming practice among farmers and specifically in extensive grazing farming systems, where growing quality fodder was the significant practice among farmers with semi-extensive grazing farming. In contrast, manure storage, planting trees and quality fodder were equally applied in an intensive grazing system. However, only 52% of farmers were aware of carbon farming practices on their farms which means that farmers are practising carbon farming unknowingly. Thus, it implies the call for carbon farming awareness level, which is still very low among surveyed farmers, especially in extensive grazing system where 90% of the respondents did not know the term carbon farming.

Ecological and financial benefits: The study reveals that planting quality fodders, trees, feeding dairy cattle with quality feeds increases dairy productivity, hence farmers' livelihood. Trees and grass improve soil fertility, erosion control, and water bank management, thus increasing crops and fodder yield. Most importantly, planting trees and fodder have been identified with high potentials for $C0_{2}$-eq sequestration. Also, for each ton of $C0_{2}$-eq sequestered, can be converted to carbon credit where farmers can earn an extra income from carbon credits dividends. The manure management through biodigesters produces biogas that serves as a source of energy for all farming system. Besides, using biogas in cooking or lighting biogas enhances farmers' livelihoods by reducing time and money spent to collect firewood and fuel use.

Carbon farming trade-off: The carbon farming practices such as fodder planting, agroforestry, and manure management have presented non-permeance and pollution swap side effects where the decrease in one emission leads to an increase of others. The intention of growing quality fodder by using heavy mechanical machines that use fossil fuels and chemical fertiliser intending to increase fodder productivity shifts CH_4 and N_2O to CO2 production. Besides, the ecological benefits increased due to manure storage lead to the increases in financial costs in terms of labour intensity or heavy investment for bio-digesters. Therefore, the decision to apply one or more carbon farming practices should consider its pollution swap or the financial trade-off for farmers; otherwise, its sustainability or carbon additionalities would not be ensured.

Carbon credits schemes: Carbon credits or emission trading schemes have been developed for both voluntary and compliance carbon markets are actively operational in Kenya where GoK and partners have developed offsetting carbon projects for the last ten years.

Cooperative entry requirement: The findings stated that cooperative members could not participate in credit schemes unless they have a carbon project. For cooperative members to participate in the carbon project must express the interest to join the project and to have met the land size or having specific project's targets practices set as projects requirements.

Carbon certification standards: The number of voluntary carbon credits certification standards is taking the lead against CDM standards in Kenya. The standards such as VERRA standards, Golden standards, and Plan Vivo standards are the most pointed popular standards in Kenya, taking into consideration the number of projects certified. Most certification standards were criticised of having a long process and high cost of project certification. Thus, different studies estimated the cost of verifying and certifying carbon projects where Plan Vivo and Gold standard were the cheapest standards at 267,500$ and 325,000$, respectively whereas VERRA and CDM certification standards were estimated at 500,000$. The results highlighted that Gold standards and Plan Vivo standards are more appropriates standards for carbon farming practices related to dairy in Kenya for their flexibility in adapting methodology. Also, Gold standards and Plan Vivo standards have high carbon credits price on the market due to the consideration of farmers' livelihood.

Quantification methodologies: The carbon farming practices identified in the dairy sector, fits in the AFOLU, grasslands, livestock & manure, and cookstoves project development areas. The sustainable Agricultural Land Management (SALM) (VM0017) and Reduction of enteric methane emissions from ruminants using 100% natural feed supplement, VM0041 carbon quantification methodologies and many more are operational and relevant in Kenya's carbon market.

The available methodologies for grasslands, livestock & manure carbon projects, can accommodate GHG emission intensity stability for by measuring the total enteric methane per unit of animal protein produced such as kilogram of milk or meat, or by measuring nitrogen fixation per hectare of land over a specific time which is a basis of measuring emission additionalities. Besides, ecosystem services such as biomass production, improve soil formation and retention, water cycling, sequestrating GHG Emission, and improved livelihood, have varies unit of measurement for AFOLU, and cookstoves projects. There is a list of operational accounting methodologies in the highlighted per sectors, as shown in appendix 1 and relevant in Kenya's carbon market.

The main objective of the study was to advise Agriterra on the viability of a business model of integrating carbon farming and carbon credits into dairy farmers cooperative business in Kenya. The study identified the viability of integrating carbon farming practices into smallholder farmers business improvement for all farming systems. The study mentioned that carbon credits dividends are almost insignificant, but carbon farming practices have severe positive impacts on the ecosystem and farmers livelihood.

6.2. Recommendation

To Agriterra: Agriterra is recommended for the following activities to sustain carbon farming practices and make cooperatives clients more bankable.

1. To increase carbon farming awareness among cooperative clients to stimulate carbon farming practices.
2. Raise funds to develop carbon farming business projects and improve the cooperative existing business model.
3. Lobbying and advocacy for multi-stakeholders involvement to reduce farmers cost of production.

Increasing carbon farming awareness: The study results revealed low farmers' awareness on carbon farming which implies the high need to invest in carbon farming practices awareness among dairy cooperatives members in Kenya, especially for farmers with extensive grazing where 90% were not aware of carbon farming practices.

Agriterra should organize a general carbon farming awareness campaigns through production and dissemination of information using mass media communication such as radio, television, and newspaper advertisements to ensure a wide range of the population is coved. Secondly, organize education and communication training sessions among cooperatives leaders and extension workers and design monitoring follow up to ensure that they disseminated the carbon farming knowledge to their farmers. Furthermore, Agriterra should involve lead milk processors and dairy certification organizations through multi-stakeholders meetings of carbon farming awareness since they have a strong influence on farmers farming systems and practices.

Carbon farming project business development: The results of the study highlighted that 100% of the farmers had more than one carbon farming practice on their farm. Nevertheless, carbon farming practices are not efficiently practised because it requires an investment to grow fodder, buy trees nurseries, or even to invest in bio-digesters. If Agriterra wants to sustainably support carbon farming practices and link them to credit schemes to benefits clients cooperatives, then it should change the working model and raise funds to develop carbon projects. Agriterra should work closer and raise carbon farming projects funds from with philanthropic foundations, multinational development agencies, and companies that have corporate social responsibilities policies that support environmental actions which are not only willing to buy carbon credits but also willing to invest in carbon farming projects development.

Lobbying and advocacy for policy changes: The results mentioned that farmers are negatively affected by the high cost of production and an unstable market. Agriterra as an expert in lobbying and advocacy should use that experience to work with milk value chain actors, and supporters to solve weak chain coordination for farmers to access consistent training, cheap loans, cheap inputs supporting services. Hence, increasing milk productivity, reduce farmers' transaction costs for the sustainability of carbon farming practices, as highlighted in the proposed new business model. Multi-stakeholder involvements of chain actors and supporters can be possible by making a memorandum of understanding and bilateral agreements for information sharing and/or setting up a common unit or focal point for the follow up of the agreed agenda on carbon farming awareness or project implementation.

For the cooperatives: Cooperatives leaders should stimulate farmers, to continue practising carbon farming practices since carbon farming can increase farmers' productivity or make their farms more resilient to climate change. Cooperatives should expand their role to stimulate carbon farming awareness by organizing regular fields visits to groups of farmers with the same collection centres.

For the government of Kenya: The study has highlighted the lack of legal framework support to carbon credits projects, which give a call to the government of Kenya to develop tax incentives and favourable policies to stimulate carbon farming practices among farmers and carbon project developers.

For donors' agencies: There is a virgin market for offsetting carbon projects in the emerging economies. Donor agencies and international organizations should invest in developing countries, offsetting projects and carbon farmers' practices to offset their emissions and improve farmers' livelihoods.

For researchers: Research organizations and feed breeders should scale up their research and advise extensive and intensive grazing farmers on the appropriate quality feed to grow and use for the improved ecosystem and increased milk productivity. Besides, the feed breeders should advise on the possibilities of using crop residues for farmers' cost-efficiency.

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8. APPENDIXES

Appendix 1: Carbon credits accounting methodologies

Carbon project sectors	Methodologies	Practices	Sources
AFOLU, Grasslands, Livestock & manure.	Quantifying N2O Emissions Reductions in Agricultural Crops (VM0022, v1.1)	Nitrogen Fertilizer Rate Reduction in soil.	(Michigan State University, 2013)
	Sustainable Agricultural Land Management (SALM) (VM0017 V1.0)	Adopting more sustainable land management practices.	(BioCarbon Fund, 2011)
	Soil carbon quantification. VM0021, V1.0	Agricultural Land Management (ALM) practices, such as grassland and rangeland restorations, reductions in soil erosion, and productivity of grassland and savanna plant communities.	(The Earth Partners, 2012)
	Sustainable Grassland Management (SGM), VM0026, v1.0	Improving the rotation of grazing animals, limiting the grazing of animals on degraded pastures, and restoration of severely degraded lands in semi-arid regions.	(FAO, 2014)
	Adoption of Sustainable Grasslands through Adjustment of Fire and Grazing, VM0032, v1.0	Adjusted density of grazing animals and the frequency of prescribed fires into an uncultivated grassland landscape.	(Soils for the Future, 2015)
	Avoided Ecosystem Conversion, VM0009, v3.0	Prevent conversion of forest to non-forest and of native grassland and shrubland to a non-native state.	(Wildlife Works, 2014)
	Revisions to AMS-III.Y to Include Use of Organic Bedding Material, VMR0003, v1.0	Methane Avoidance through Separation of Solids from Wastewater or Manure Treatment Systems. Revised from CDM methodology AMS-III.Y	(NativeEnergy, 2012)
	Reduction of Enteric Methane Emissions from Ruminants using 100% Natural Feed Supplement, VM0041, v1.0	Estimate enteric methane (CH_4) emission reductions generated from the inhibition of methanogenesis by using natural feed supplement into ruminants' diet.	(Zoupanidou, 2019)

Source: Author 2020

Appendix 2: Farmers survey questionnaire

<u>**Farmers Survey 2020**</u>

This questionnaire is prepared to study the sustainable carbon farming and carbon credits business models for smallholder dairy cooperatives in emerging economies; a case of KENYA for AGRITERRA. We respect your time to fill this short questionnaire, and we want to assure you the highest level of confidentiality about information obtained from you and thank you for your cooperation in assisting us with the research. This survey takes 20-30 minutes to fill.

Section 1: About you and the cooperative

1. What is your gender?

- ◉ Male
- ○ Female

2. What is your age? ………………

3. What is your highest education level?

- ○ None
- ○ Primary
- ○ O-levels
- ○ A-levels
- ○ TVET or College
- ○ University Degree

4. Are you Agriterra cooperative member?

- ○ Yes
- ○ No

5. What is the name of your cooperative?

……………………………………

6. How many years have you been in this cooperative?

[ ]

Section 2 Carbon farming awareness among farmers

In this section, questions refer to climate change and carbon farming practices

7. Have you ever heard about climate change?

Climate changes here it means global warming or increase in the average temperature, change in seasons reveals in the form of droughts, flooding, disease outbreaks or erratic rainfall.

- ○ Yes
- ○ No

8. If yes, what do you know about climate change (CC)

………

………………………………………………………………………………………

9. Are you aware that dairy farming can contribute to the CC?

- ○ Yes
- ○ No

10. If yes, which dairy farming activities can contribute to the CC?

………

………………………………………………………………………………………

11. Have you ever heard about carbon farming?

Carbon farming practices, we mean Land management, way feeds are grown, manure management.

- ○ Yes
- ○ No

12. If yes, what do you know about it?

……

13. Have you ever heard about carbon credits?

- ○ Yes
- ○ No

14. Have you ever participated in a carbon credits project?

- ○ Yes
- ○ No

15. If yes, what do you benefit?

……

16. Would you get interested if your cooperative decides to join carbon credits?

- ○ Yes
- ○ No

17.If yes or no, what is your reason?

……

18. Which of the following farming practices are applied on your farm?

- ☐ Planting fodder
- ☐ Planting trees
- ☐ Manure storage
- ☐ Bio-digester
- ☐ None

Section 3: Farming and feeding system

In this section, the questions are regarding how your farm and how you feed cattle.

19. What type of dairy breed do you keep on your farm?

- ☐ Local breed
- ☐ Exotic breed
- ☐ Crossbreed

20. How many acres of land is your farm?

[ ]

21. Do you farm on your own or leased land?

- ☐ Own land
- ☐ Leased Land

22. How many acres of land is your own?

[ ]

23. How many acres of land do you lease?

[ ]

24. Is your farm flat or Slope?

- ○ Flat
- ○ Slope

25. What is the position of the ban on your farm?

- ○ In the middle of the farm
- ○ On top of the farm

26. Do you produce animal feed on your farm?
- ○ Yes
- ○ No

27. If yes, what are the types of feed produced?

……

………………………………………………………………………………………

28. How many acres of land do you allocate for feed production?

[ ]

29. Do you produce food crops on your farm?
- ○ Yes
- ○ No

30. If yes, what are the types of food crops produced?

……

………………………………………………………………………………………

31. How many acres of land do you allocate for food crops production?

[ ]

32. Do you have pasture on your farm?
- ○ Yes
- ○ No

33. If yes, what are the types of grass are on your land?

……

………………………………………………………………………………………

34. How many acres of land is a pasture on your farm?

[ ]

35. Do you intercrop you on your land?
- ○ Yes
- ○ No

36. If yes, which crop or fodder do you intercrop you on your land?

……

37. Do you graze your cattle?
- ○ Yes
- ○ No

38. Do your graze your cattle on your land or Public?
- ● Own land
- ○ Public land

39. How many hours do you graze your cattle per day?

[ ]

40. Do you feed for your cattle inside the ban?

- Yes
- No

41. Do you purchase feed for your cattle?

- Yes
- No

42. If yes, what did you purchase?

- Forages
- Crop residues
- Concentrate
- Other specify

43. What is the price of forages purchase per kg?

44. What is the price of Crop residues purchase per kg?

45. What is the price of concentrate purchase per kg?

46. What is the total estimated cost of feed per year?

47. What is land preparation methods on your farm?

- Hoe
- Animal
- Machine

48. Do you plough your land to control weeds?

- Yes
- No

49. Which types of crop or feed do you plough?

……

Section 4: Milk Production and selling

In this section, questions of milk yield and revenues

50. What are the average litres of Milk do you produce per day per lactating cow?

51. How many days do you milk your cattle before it gets dry?

52. How many days do your cattle stay dry?

53. What is your average milking cows per day?

54. How many litres of Milk do you sell per day?

55. What is the price of Milk per litre (Kesh) at your selling point?

56. If you sell Milk, where do you sell the Milk?

- ☐ At farm gate
- ☐ To middlemen
- ☐ To cooperative
- ☐ To local market
- ☐ To hotels or café
- ☐ Other (specify)

Section 5: Manure management & Application systems

57. Do you keep cattle in the barn?

- ○ Yes
- ○ No

58. If yes, do you separate manure from urine?

- ○ Yes
- ○ No

59. If yes, how do you separate manure from urine?

60. How do you store manure on your farm?

- ☐ Solid storage
- ☐ Dry lot
- ☐ Liquid/Slurry
- ☐ Anaerobic digester
- ☐ Composting
- ☐ None

61. Do you use manure on your land?

- ○ Yes
- ○ No

62. Where did you put unused manure?

………

63. Why did you decide not to use your manure on your land?

………

64. If yes, do you spread manure on pasture in your farm?

- ○ Yes
- ○ No

65. Do you spread manure on food crops on your farm?
- Yes
- No

66. Do you spread manure on the feed land on your farm?
- Yes
- No

67. Do you Inject manure in soil?
- Yes
- No

68. How much of the manure goes back on your farm?
- All
- most of it
- Half
- Little
- Not at all

69. Do you use manure as Biogas generation?
- Yes
- No

70. If yes, do you spread liquid/Slurry on your farm pasture?
- Yes
- No

71. Do you spread liquid/Slurry on your food crops?
- Yes
- No

72. Do you spread liquid/Slurry on your land?
- Yes
- No

73.if no, do you Inject liquid/Slurry in soil?
- Yes
- No

74. If manure is used as Biogas, what is the estimated cost to make one biodigester?

75. Is there any money-saving you are making by using Biogas?
- Yes
- No

76. Do you use manure as a construction material?
- Yes
- No

77. Do you use manure as dry dung for fuel?
- Yes
- No

78. Do you sell manure?
- Yes
- No

79. If yes, what are your estimated annual revenues from manure?

Section 6: Main cost and revenue streams

80. What is the main source of income for your farm?
- Selling Milk
- Selling live animals
- Selling Feed

81. Is there any other source of income?
- Yes
- No

82. Can you list other sources of income

……

Section 7: End of the form

Thank you very much for your cooperation

Appendix 3: Cooperative Leaders survey questionnaire

Cooperative Leaders Survey 2020

This questionnaire is prepared to study the sustainable carbon farming and carbon credits business models for smallholder dairy cooperatives in emerging economies; a case of KENYA for AGRITERRA. We respect your time to fill this short questionnaire, and we want to assure you the highest level of confidentiality about information obtained from you and thank you for your cooperation in assisting us with the research. This survey takes 15-20 minutes to fill.

Section 1: About you and the cooperative

1. What is your gender?
- Male
- Female

2. What is your age?

3. What is your highest education level?
- None
- Primary
- O-levels

- A-levels
- TVET or College
- University Degree

4. What is the name of your cooperative?

………

5. How many registered members are in the cooperative?

6. How many are female members?

7. How many are young members?

Bellow 35 years of age

8. Who are the key partners in your cooperative?

Put the names of your supporters, banks or any other organization that you work with if any?

………

9. Which of these functions are performed by your cooperative?

- Input (feed provision)
- Dairy
- Collection
- Processing (packaging)
- Wholesale and or Export
- Retail

10. Have you ever heard about certifications?

- Yes
- No

11. Do you work with any certification company?

- Yes
- No

12. If yes, list the names of certification companies you work within your cooperative?

………

Section 2: Carbon farming awareness among farmers

In this section, questions refer to climate change and carbon farming practices

13. Have you ever heard about climate change?

Climate changes here it means global warming or increase in the average temperature, change in seasons reveals in the form of droughts, flooding, disease outbreaks or erratic rainfall.

- Yes
- No

14. If yes, what do you know about climate change (CC)

………

15. Are you aware that dairy farming can contribute to the CC?

○ Yes

○ No

16. If yes, which dairy farming activities can contribute to the CC?

………

17. Have you ever heard about carbon farming?

Carbon farming practices, we mean Land management, way feeds are grown, manure storage and use of Biogas.

○ Yes

○ No

18. If yes, what do you know about it?

………

19. Do your farmers practise carbon farming?

○ Yes

○ No

20. If yes, can you list down carbon farming practices?

………

21. Which of the following practices are applied by farmers in your cooperative?

☐ Planting fodder

☐ Planting trees

☐ Manure storage

☐ Biodigester

☐ None

22. What are the challenges or disadvantages faced by farmers while using the above practices?

………

23. What are the benefits farmers gain in using the above practices?

Financial and non-financial benefits

………

24. Have you ever heard about carbon credits?

○ Yes

○ No

25. Is your cooperative a carbon credits member?

○ Yes

○ No

26. If yes, what does your cooperative gain for carbon credits benefits?

………

Section 3: Farming and feeding system

In this section, the questions are regarding how your farm and how you feed cattle

27. What type of dairy breed is dominant in your cooperative?

○ Local breed

○ Exotic breed

○ Crossbreed

28. What is the proportion of farmers who does grazing?

- All
- Most
- Half
- Few
- Non

29. In your cooperative, do you graze on your land or Public?

- Own land
- Public land

30. In your cooperative, what is the proportion of farmers who graze on the public land?

- All
- Most
- Half
- Very Few
- Non

31. In your cooperative, what is the proportion of farmers who do purchase feed for their cattle?

- All
- Most
- Half
- Very Few
- Non

32. What is the most purchased feed by your farmers?
Answer the main practice

- Forages
- Crop residues
- Concentrate
- Other specify

33. What is the common land preparation methods on your cooperative?

- Hoe
- Animal
- Machine

34. What are the challenges do farmers face related to animal feed?
………

Section 4: Manure management & Application systems

35. In your cooperative, what is the proportion of farmers who keep cattle inside the ban?

- All
- Most
- Half
- Very Few
- Non

36. If they do separate manure from urine, how do they do that?

……

37. What is commonly done for manure storage by farmers in your cooperative?

- Solid storage
- Dry lot
- Liquid/Slurry
- Anaerobic digester
- Composting
- None

38. What is the main use of manure by farmers in your cooperative?

- Spread to crop or fodder
- Spread on pasture
- Biogas generation
- Sell manure
- Dry dung for fuel
- As construction material
- Injected on soil

39. What is the estimated number of farmers with biodigester in your cooperative?

[ ]

40. What is the estimated cost for one medium standard biodigester in your cooperative?

[ ]

41. From your point of view, is there any benefits of using Biogas?

- Yes
- No

42. What are the benefits of using Biogas?

……

Section 5: Main cost and revenue streams

43. What are the main sources of income for farmers in your cooperative?

- Milk selling
- Selling live animals
- Feed selling

44. Is there any other source of income for farmers in your cooperative?

- Yes
- No

45. Can you list other sources of income?

Put the names

……

Section 6: End of the form

Thank you for your cooperation and for responding to this questionnaire. You can submit it now.

Appendix 4: Online key-informants interview.