Reduction of Food losses along the Meru avocado value chain in Kenya

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and

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Dedication

I dedicate this document to the Almighty, to my beloved children, my lovely mother and my sister Logose Mary Gorretty

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List of acronyms and abbreviations

%	Percentage
AFA	Agricultural Food Authority
ANOVA	Analysis of variance
APHLIS	Agricultural Post Harvest loss information system
CABI	Centre for Agriculture and Bioscience International
CO_2	Carbon dioxide
FAO	Food and agriculture organization
FOQLAB	Food Quality Living Laboratory
GDP	Growth Development Profit
GT	Ger tons
HCD	Horticultural Crops Directorate
KALRO	Kenyan Agricultural and Livestock Organization
KEPHIS	Kenyan Plant Health Inspectorate Service
Kg	Kilo gram
KNBS	Kenyan National bureau of Standards
KSE	Kenyan shillings
LCA	Life Cycle Assessment
NARIGP	National Agriculture and Rural Inclusive Growth Project
^oC	Degrees Centigrade.
PCPB	Pest Control and product board
PESTEC	Political Economic, Social, Technological, Environmental, Cultural
SDG	Sustainable Development Goals
SPSS	Statistical Package for The Social Sciences
SWOT	Strength, Weakness, Opportunity Threats
USAID	United States Agency for International Development

Abstract

Avocado farming is a popular enterprise among small holder avocado farmers in Meru-County Kenya. The sector is rapidly growing and the country is ranked as the 6th world producer of avocado. However, the developed avocado value chain is experiencing high food losses along different phases of the chain. This hinders the sector's sustainability and is limiting competitiveness for the growing demand. A study on reduction of food losses along the Meru avocado value chain was conducted in Meru County, with key considerations on the involved stakeholders and their roles, food loss causes and food loss hot spots, current food loss reduction measures and food loss impacts.

A total of 85 respondents participated in the study. Three focus group discussions were held, 30 participants who included chain actors, supporters and Abogeta management team to collect data on the current context of the value chain. Structured survey questionnaires were administered to all 85 respondents to gather quantitative data on food losses, their causes and currently used food reduction measures. And 40 key informants who included actors and supporters were interviewed.

The obtained quantitative data was processed and analyzed using excel spread sheets and SPSS package 26, and qualitative data was analyzed using chain map, stake holder matrix, PESTEC and SWOT. The results were presented using pie charts, bar graphs and tables.

Finding show that there is an existing value chain with various stakeholders taking roles as chain actors or supporters. The product flow for export exits production units through five channels. The study result also indicates that the major supporter of the chain is the Kenya government through Ministry of Agriculture , fisheries and livestock. Further results indicate that the chain has governance structures and policies though there are weakly implemented.

The study investigated food losses at various stages along the chain and the result show that losses occur at every stage of the chain though amounts lost differ. Findings from the study indicate that the entire chain experiences 53% food losses. Further assessment on existing hot spots indicate that harvesting contributed to the highest food loss percentage which amounted to 20.25% food loss, both post-harvest handling, aggregation and transportation were contributing 6.25% and during storage 5.25% was lost.

Study findings suggest that the observed food losses are caused by socioeconomic factors like high poverty levels among farmers that limit access to credit. Secondly, the losses are incurred as a result of institutional factors that include weak governance structures and regulations. More pronounced was the technological factors. where key informants revealed that the sector is faced with a challenge of inadequate technologies for appropriate handling of the product.

Conclusions were suggested that, though the existing value chain is facing high food losses, it has influential stakeholders, opportunities for chain upgrading to reduce food losses.
Therefore, its recommended that the governance structures be improved and develop public -private partnerships to facilitate collective action toward food loss reduction in the chain.

Key wards, Food loss, Food loss hotspots, value chain, stakeholders

Chapter 1. Introduction

The term food loss refers to that food that gets spoilt, spilled, or incurs reduction in value and quality along the food supply chain (Snel *et al.,* 2021). Typically, food losses take place at production, post-harvest handling, storage, transportation, processing and distribution stages of the supply chain (Parfitt *et al.,* 2010 and Magalhaes *et al.,* 2021). Although total amounts of percentage loss depends on the food type, generally, highest percentages of post-harvest food losses have been recorded in perishable products especially fresh fruits like avocados among others (Gustavsson *et al.,* 2011).

Considering avocado as one of the widely produced and traded fruit in various parts of the world,significant food losses along its value chain indicates substantial losses of resources such as land, agricultural inputs, water and labour (Gustavsson *et al.,* 2011). Global quantitative estimations show that one third of avocados meant for human consumption is lost along the chain annually (FAO, 2014). However, there is a distinct difference in food loss stages between the low income and high-income countries. Most developed countries experience food losses during distribution and consumption, while lower income countries experience high food losses at production and postharvest handling (Skoet, *et al.,* 2020).

High income countries such as Mexico and Colombia producing over 50% of the global avocadoproduction and the leading exporters of avocados are experiencing less 15% avocado food losses along the supply chain (Minagricultura, 2014). While developing countries such as Kenya, currently ranked as the fifth largest avocado producer worldwide and the third exporter in Africa,is experiencing losses estimated at 60 % of the total production along its supply chain (Snel *et al.,* 2021). From the economic perspective, the lost quantities lower the country's Gross domestic profit(GDP), which is necessary for economic development. Besides, the current food loss percentages indicates remarkable footprints in influencing farmers' livelihoods and environmental health (FAO, 2013,2015).

1.1.Background.

In the last decade the avocado market has been flourishing globally(Naamani, 2011). The European market is increasingly growing with anticipations that it will triple overtime before reaching maturity (Takadi, 2018 and Amare *et al.,* 2019). Yet the current top producers and suppliers in the world market (Mexico and Colombia) (Statista, 2022) may not be able to meet desired quantities throughout the year because their weather conditions and short harvest periods Motaung,(2019), confine their supply to limited months of the year (Naamani, 2011, Bustos and Moors, 2018).

This offers a high potential to African countries such as south Africa and Kenya to competitively capture the global markets because the countries have favorable climatic and environmental conditions that facilitate production throughout the year (Muthomi, (2019 and Ringo, *et al.,* 2022). However most developing countries are faced with a challenge of high postharvest food losses (Skoet, *et al.,* 2020).

Timmermans, *et al.,* (2014) suggest that, developed countries have been able to penetrate global markets and maximize profits because high investments have been put in postharvest loss reduction technologies. According to

FAO (2011), Gustavsson *et al.,* (201) and Rosegrant *et al.,* (2018), most developed countries have been able to cutdown postharvest food losses to less than 10 %. Naamani, (2011), indicated that the avocado value chains of the world leading producers and suppliers (Mexico and Peru) are experiencing about 7% food losses along their value chains.

Comparing that to other promising countries such as South Africa, which is currently the leading producer and exporter in Africa, its value chain experiences 20 % food losses (Ramírez-Gil *et al.,* 2019), but the country has been experiencing gradual decline in production since 2017 as a result of longer drought periods (Randela, 2018). This existing challenge opens higher opportunities for other African countries especially Kenya (Takadi, 2018).

Kenya is recognized as the sixth significant avocado producing country worldwide and the second in Africa (Statista, 2022). Within the country, avocado is ranked as the fourth important national fruit crop and the number one fruit being exported to European and middle East countries (Ringo *et al.,* 2022). Avocado export accounts for approximately 17% of total horticultural exports in Kenya (Kenneth, 2022). Besides, the crop provides livelihood to over 85% of the Kenyan small-scale farmers and generate forex revenue to the economy (Wasilwa *et al.,* 2004).

According to Muthomi, (2019), avocado production is spread throughout the year because of favorable climatic conditions, fertile soils and different ecological zones that differentiatematurity periods depending on the location. The subsector is rapidly developing and has resulted into a shift transformation in land use in most parts of Kenya (Muthee *et al.,* 2015 and Snel *et al.,* 2021).

Currently, avocado production is practiced in Murang'a, Nyeri, Kiambu, Kisii, Nandi, Meru and the entire Mt. Kenya region (Kathula, 2021). The predominant producing group contributing of over 70% of the total production are the small-scale farmers (Amare *et al.,* 2019), Although in the past ten years commercial producers have emerged and to date commercial production is estimated at 7500 hectares, moreover, this is expected to increase by 1500 hectares by 2030 (Amare *et al.,* 2019).

A study report from (Snel *et al.,* 2021), indicated that there was a drastic increase in production between 2018 and 2020 that lifted produced figures from 234,000 metric tons in 2018 to 800,000 Metric tons in 2020. This prompted small scale farmers to organize themselves into co-operatives for better engagement in both local and international avocado value chains (Isaboke and Ndirangu, 2021). However, this arrangements and the developed value chain supplies small shares of 26% to the local market and only 14% of the total production is exported. This indicates that approximately 60% of the production is lost along different stages of the value chain (Snel *et al.,* 2021).

1.2. Problem statement

The growing global market together with the increasing production offer the Kenyan avocado subsector a higher potential to diversify the avocado export portfolio, however, the developed value chain is currently experiencing challenges of high food losses. This is hindering Kenya's avocado export value chain to meet quantitative and

qualitative market demands. Moreover, those losses also have severe negative impacts on global food system sustainability and environmental health. It's worthwhile to assess food losses along the chain and suggest food loss reduction measures that will enhance food security and environmental health. This further will improve the livelihoods of many small holder farmers and reduce the country's dependency on foreign support.

1.3. Problem owner

The problem owners are Meru avocado farmers' cooperative and SIA project "Food Waste Reduction and Food Quality Living Lab (FORQLAB)". FORQLAB is a European project formulated by a consortium of experts and is partnering with small scale avocado producers in Meru. The general aim of the cooperative is to establish reliable market for their products while FORQLAB aims to develop new knowledge and action perspectives for local entrepreneurs through practice-oriented research.

1.4. Rationale

To achieve Sustainable Development Goals (SDG) 1,2,3 aiming at reducing food losses along thesupply chains to a halve per capita global food by 2030, and increasing environmental sustainability, it's important that studies on reduction of food losses along value chains are conducted in order to develop appropriate food loss reduction strategies along any given chain.The results of the study will provide baseline information that will be used for development of policies and for assessing the impacts of the developed strategies on food loss reduction along the avocado value chain.

1.5. The study objective

The general objective of the study was to assess qualitative and quantitative food losses along the avocado value chain in Meru Kenya and suggest technical measures that can be implemented to enhance reduction of food losses along the chain.

1.6. Research questions

Main research question.

What are the quantitative and qualitative food losses along the Meru-Kenya avocado value chain?

Sub questions

i) What are the roles of the Meru avocado value chain actors and supporters?

ii) What is the Meru avocado value chain governance structure?

iii) What quantities are lost at different stages in the existing value chain?

iv) What technological, institutional and economic factors are influencing food losses in the chain

v) What are the impacts of the observed losses

vi) What strategies are currently being implemented to reduce avocado food losses along the chain?

Chapter 2. Literature review

This chapter presents reviewed literature on the different topics from previous studies related tofood losses. The information was obtained from related studies, publications, project reports, existing data bases, nongovernment and government publications. The information was accessed through online search engines such as Green i, google scholar, science direct, CABI, Textbooks,Journals among others.

2.1. Avocado production.

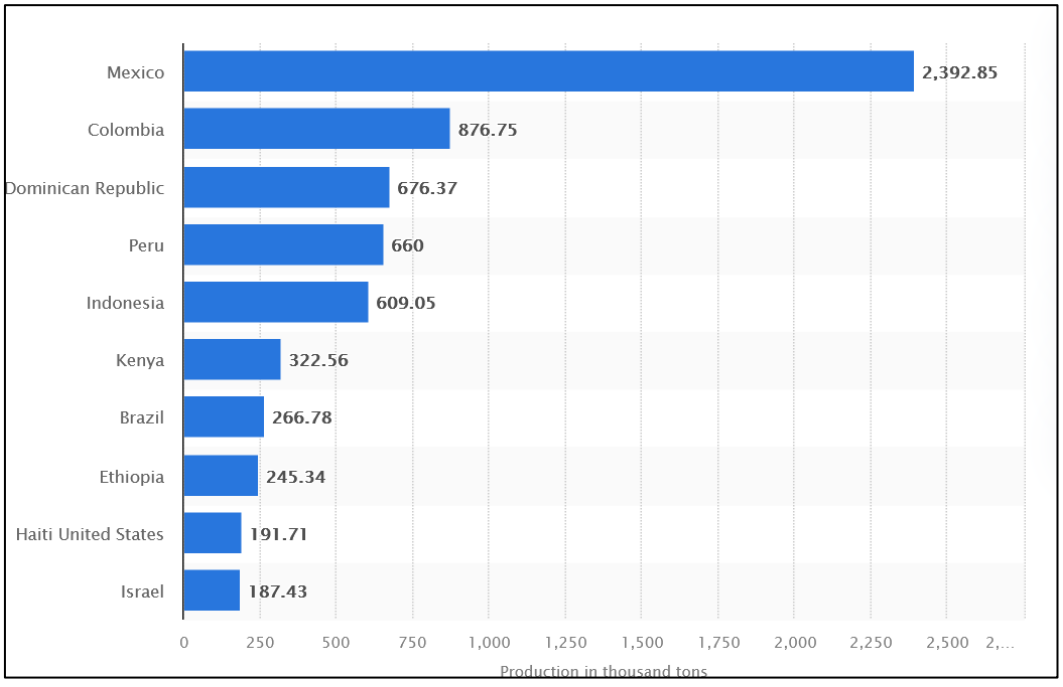
Avocado (*Persea americana*) is a fruit tree that is native to Mexico and central America though it production spread to most parts of the world in the past 100 years (Chen *et al.,* 2009). Commonly known races grown in most parts of the world Mexican, Guatemalan and west Indian (Ayala and Ledesma, 2014), and have a maturity period between three to five years before bearing fruits.

Its production requires well drained soils with a pH range 6.2 to 6.5, temperature range between 10^{o}C to 35^{o}C (Chen, *et al.,* 2009 and Schaffer *et al.,* 2013). Mature trees produce between 200 to 500 fruits per year and the fruits appear in various shapes and colours (Orhevba and Jinadu, 2011).

2.1.1. Global production

According to reports from *Statista, 2022*), There has been an increasing production from 2000 to date the total worldwide estimated avocado production is 8.059 359 metric tons, with Mexico being the leading producer supplying about 32% of the worlds production, followed by Colombia. Kenya is the sixth largest producer worldwide (Figure 1), second largest producer and exporter in Africa.

Figure 1.Estimated global Avocado production per country



Source: Statista, 2022

2.1.2. Comparative advantage the leading producers have over other countries.

According to Ayala and Ledesma (2014), the leading avocado producers and exporters to sustain their position in quantities produced and exported depended on the developed domestic market. Mexico, California and Peru present the best example. Over 70% of Mexico's production is locally consumed. Similarly, California and Peru's domestic market consumption ranges between 60%to 70% of their production (Naamani, 2011).

This offered an opportunity for those countries to extend to export industry, that gradually grew alongside the domestic market and enhanced production of larger volumes (Martínez *et al.,* 2014). This approach reduced the amount of food lost in the avocado value chains of those countries because the surplus or grades that do not meet export requirements are consumed domestically (Chauhan, *et al.,* 2021).

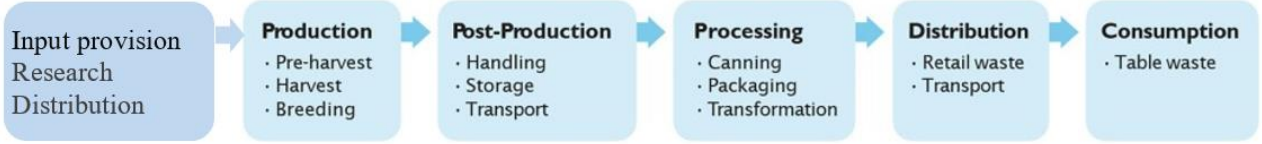
Other relevant aspects as pointed out by Agu-Aguiyi *et al.,* (2020) suggest that farmers' organization into local associations enabled a country like Mexico to build strong market structures and ease extension service delivery. That was coupled with policies and regulations such as strict regulation on maturity requirements and quality standards implemented by Mexican government (Gibbon *et al.,* 2008).

Further investigations by Ayala and Ledesma (2014) reveal that most leading producers have invested and improved technologies for avocado production, handling and processing. Moreover, their governments have subsidized agricultural inputs such as pesticides, fertilizers and machinery to facilitate easy acquisition by farmers and enhance proper handling to reduce losses at all levels (Bustos and Moors 2018).

2.2.Value chain analysis

Kaplinsky and Morris, (2000), "The value chain describes the full range of activities which are required to bring a product or service from conception, through the different phases to final consumers and or final disposal after use. In the global food industry, the concept of 'value chain' is comparatively new. The idea was developed from Netherlands with the formulation of the Foundation Chain Competition Agri-food in the 1995 (Kaplinsky, 2000). Recently, value chain trainings and innovations are a strategies developed to reduce food losses and to improve competitiveness in agribusiness (Delgado, *et al.,* 2017, Bustos and Moors, 2018). Outstandingly, the approach helps to segment activities (Figure 2) that form and look for value addition to the final product (Walters and Rainbird, 2007).

Figure 2.Segmentation of value chain activities



Adopted from: Kaplinsky and Morris, (2000).

Further, value chain approach supports analysis of characters between diverse links that comprise and aim to

understand the factors affecting the competitive advantage, assess their relative impact for better definition of priorities and strategies of strenuous action between different actors (Martínez Arroyo *et al.,* 2014). Most developed countries such as the Netherlands, Mexico and Colombia have adopted value chain approach to ensure systemic competitiveness to meet the growing need for labour division (Gibbon *et al.,* 2008).

Secondly, it increases efficiency in production and reduces food losses along the chain because resource allocation is directed to areas that are pertinent to adding value and supports better understanding of dynamic factors within the whole value chain, (Gereffi and Christian, 2009).

2.3.Chain governance

According to Gereffi *et al.,* (2005) and Zamora (2016) chain governance is the distribution of authority and power relationships among chain actors to determine how financial, material, and human resources are allocated and flow within a chain. This Leverage the chain Robustness, Resilience and Reliability (Matui *et al.,* 2016).

Taking examples of Mexico and the Netherlands currently using the value chain approach, the competitive advantage their value chains have over those in developing countries is the governance structure. where they have an economic industrial Organization that structures the product market, cooperate behavior and social market benefits that facilitate food loss reductionin their chains (Walters and Rainbird, 2017).

Divergent from what is observed in developed countries, Martínez Arroyo *et al.,* (2014) contend that high food losses along value chains of most developing countries are resulting from poor chain governance and organization. For example, 70% of avocados exported from Kenya are produced by small scale farmers with less formal organization, weak governance structures that can create linkages to exporters or processors. This has increased high food losses since farmers are not able to understand quality requirements of the market (Amare *et al.,* 2019).

2.4.Food loss quantification and food loss hot spots in avocado value chains

2.4.1.Food losses

Food losses refers to that food that incurs abnormal intrinsic and extrinsic reduction in quality and quantity such as rotting, wilting, bruised or getting spoilt, spilled and or else disappearing before reaching the final consumer (Lipinski *et al.,* 2013). This study considered food losses as any food that leaves the export and local avocado chain for any other reason rather than the intended chain. Major food losses occur after harvesting and add up along different stages of the food supply chain (Parfitt, *et al.,* 2010).

The occurrencesof those losses have direct consequences on the social and economic conditions of the chain actors especially those in developing countries (Delgado, *et al.,* 2017). Other consequences are related to wastage of limited resources such as land, water, labor and money (Timmermans *et al.,* 2014 Willersinn *et al.,* 2017). Moreover, those are also associated with environmental health destruction through deforestation, biodiversity loss and emission of unnecessary gases such as CO_2 (FAO, 2013).

Food losses are caused by inadequate technologies, poor transport facilities, inappropriate infrastructure for various processes along the chains, bad packaging, limited handling skills, incomplete market information flow and

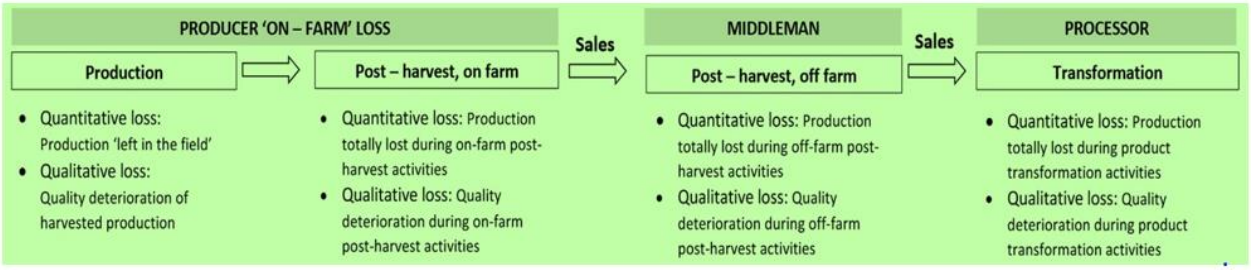
weak collaborations within key market segments (Gustavsson *et al.,* 2011). Addressing food losses in the early stages of the food supply chain would reduce far reaching consequences on the economic, social and environmental aspects (Tayyib and Golini, 2016).

2.4.2.Food loss occurrence hot spots

The avocado value chains experience qualitative and quantitative food losses at every stage along the value chain including during transportation, distribution and consumption. Delgado *et al., (*2017) in their described how losses occure at different stages of product flow and further suggested that quantitative and qualitative losses are recorded as presented in figure (3).

According to APHLIS, (2014) quantitative food loss is the reduction in food product weight and this can be transformed into caloric terms. while qualitative food loss isdescribed as loss of nutritional content and physical appearance of a given food product(Affognon, *et al.,* 2014). Conclusions drawn from survey studies conducted by FAO (2011, 2013), on food losses suggest that, if the food loss at a given stage of the chain exceeds 5% of the total production, it poses a threat to that chain and should be treated as a hot spot for immediate interventions.

Figure 3.Description of quantitative and qualitative food losses along value chains.



Source: (Delgado, et al., 2017).

2.4.3.Food loss quantification

According to Gustavsson *et al.,* (2011) food losses should be estimated from on farm activities, such as crop management harvesting through the chain to consumption. Considering the avocado export value chains, as suggested by World economic forum (2019), quantitative and qualitative food losses differ at every stage. At farm level especially harvesting, farmers, experience food losses ranging between 15 % to 25%. While during transportation, about 5-10%, at processing and packing, about 3-10% food loss may be registered. During shipment/exportation, food losses ranging between 1-5% (Amare *et al.,* 2019).

2.5.Factors influencing avocado food losses along the value chain

Food losses along any given value chain differ depending on the country. However, studies conducted by Luo *et al.,* (2021) suggest that causes are related to poor management and governance, inadequate technologies for various operations at every stage, institutional factors and the socio-economic status.

2.5.1.Poor management

Poorly managed chains experience a lot of challenges that lead to high food losses (Walters and Rainbird, 2017). Management aspects that oversee the organization of products, logistics of moving the product from production till

final distribution are important in any given value chain (Gstraunthaler, 2010). Further Gibbon and Ponte, 2008, indicate that for proper management of any value chain, clear governance structures that involve all actors should be put in place. This can help build chain robustness, resilience, reliability and smooth flow of the products to reduce food loss (Zamora, 2016 and Matui *et al.,* 2016).

2.5.2.Technological factors

According to reports by WRAP, (2012), Vegetables and fruits such as avocado, perishability is an important concern in their supply chains. Development of appropriate technologies for handling, producing and value addition should be developed to prevent food losses. Rana and De Cesare, (2021) insist that technologies to manage the handling of perishable products are required to reduce adverse conditions during harvesting,storage and transportation. Food supply value chains in poor countries with insufficient technological infrastructure such as transport and logistics are faced with huge foodlosses (Shepherd, 2013). Further, these insufficiencies also limit the chain actors ability to respond to market demand since quality and quantity are compromised (Yadav *et al.,* 2022). Research results from studies conducted by (Moïsé *et al.,* 2013) revealed that improving transport and trade-related infrastructure quality by 10 % can reduce food losses in any given chain and increase agricultural export by approximately 30 %

2.5.3.Institutional factors

Institutional factors can be defined as internal and external factors that influence activities of a given value chain. These include competition, economic constrains, standards, financial legislations, culture, organizational strategy and characteristics (Canali *et al.,* 2016). From a value chain perspective, institutional factors are categorized into, (i) Normative and mimetic- which depend on the structuring of the organization, (ii) Economic andcoercive, that perform irrespective of the organizational structures (Zattoni and Cuomo, 2008; Gstraunthaler, 2010). Those factors influence food losses at organizational and environmental levels due to their influence in internal and external environments of any given value chain.Inefficiency in institutional factors lead to unavoidable food losses along any value chain (Canali,*et al.,* 2016).

2.5.4. Socio-economic factors

One of the most important influencers of food losses along any given food value chain is the attitude of involved actors. Studies conducted by (Chauhan *et al.,* 2021)suggest that the attitude of conduct such as mishandling, inadequate planning and management of necessary activities play an important role in the quantities of food lost along the chain.

Coupling that with limited access to market information (Parfitt *et al.,* 2010), farmers produce with less knowledge about market requirements, this results into rejection of over 50% of the produce supplied to the market(Herzberg *et al.,* 2022) and such rejected food is considered as food loss. Besides limited access to market information by small holder farmers, most value chain actors in developing countries have limited access to necessary extension services such as product management strategies and logistics (Agu-Aguiyi *et al.,* 2020).

From the economic perspective, national wealth variations across countries directly impact on food losses in value chains (Chalak *et al.,* 2016). Poor economic status in most developing countries limit chain actors capability to access capital necessary for infrastructure development and technological adoptions to reduce food losses (Trienekens, 2011).

2.6.Food loss impacts

Food losses along the avocado value chain have significant economic and environmental impacts.From a general angle, global food losses are estimated at an economic value of 10000 billion dollarsannually (Muriana, 2017).

2.6.1.Economic impacts

Engagement in avocado value chain by involved countries has generated economic revenue to the countries as well as the actors. According to FAO, (2011), high food losses along the value chain have direct negative impacts on the income of involved actors. Countries whose value chain experience high food losses lose a certain amount of revenue that could be earned from the quantities lost (Govindan, 2018 and De Steur *et al.,* 2016).

Besides, high food losses reduce the quantity of products available to the market. Moreover, at higher levels of the chain, food losses affects the pricing policy (Seberini, 2020). While at consumer economic perspective, this leads to high food prices due to the imbalance between food supply and demand (Rutten, 2013). Resultingly, experienced food losses limit access to food and may lead to malnutrition which it its self-hinders economic development

2.6.2.Environment impacts

Despite the economic value and successful production of avocados in various parts of the world,incurred food losses have substantial environmental impacts. Food losses account for 28 percentof the global cropland area, 23 percent of the world fertilizer use, 24 percent of freshwater used for its production and contribute 8 percent 3.3G tons of Carbon dioxide (kummu *et al.,* 2012).

Annual estimation on carbon footprints contribution from food losses were noted at 3.3 Gt CO_2 Carbon (FAO, 2013). While studies by Qin and Horvath, (2020) on the contribution of food losses to carbon footprint, affirm that a small pack of two avocados (approximately 600g) has carbon emission footprint of 846.36kg CO_2. Similar observed were made by Salemdeeb *et al., (* 2017) when using environmental extended input-output method.

Reutter *et al., (*2017) and (Lam *et al., (*2018) in the Life cycle assessment (LCA) method of environmental impacts of food losses reveal resources depleted during the production of lost amount are put to waste. More affirmation by Scherhaufer, *et al.,* (2018), reveal that food loss result into severe environmental problems such as green-house gas emission.

2.7.Food loss reduction strategies

According to Zorya *et al.,* (2018), food losses destabilize the resilience and sustainability of food systems. Development of global and national food loss reduction measures is required. Rosegrant *et al.,* (2018) suggest that for food loss reduction to be achieved, governments should be ready to invest in appropriate technologies that help reduce food losses at every segment of food supply chains.

Further, kaminski and Christiaensen, (2014) emphasize that more education on postharvest management measures will play a big role. They further argue that the education should be coupled up with economic incentives such as improvement of infrastructure that easeaccess to markets and market information.

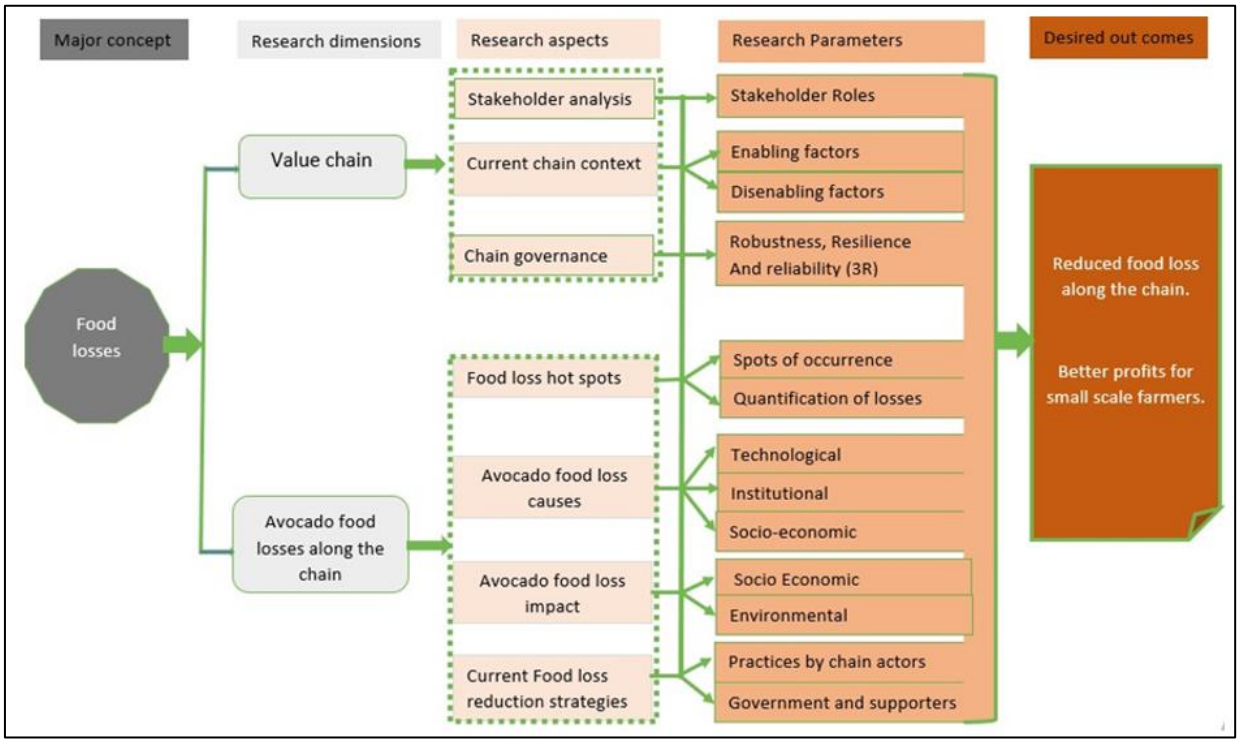
Soosay *et al.,* (2008) note that innovative collaborations is one of the possible avenues for achieving food loss reduction along the value chain because firms have different capabilities that can efficiently be allocated through collaboration with other partners. Besides the above-mentioned suggestions, Koester, (2014) points out that to achieve food loss reduction as included in the sustainable development goal 1,2,3, strengthening and re-enforcement of supportive policies and structures is required.

2.8.Conceptual framework

A conceptual framework figure (4) demonstrates how the major concept of the research recount with the research dimensions, aspects and parameters and how the research out comes will contribute to the expected avocado value chain. The framework points out how the food losses along the value chain needed to be rationalized for the development of sustainability and profitability.

To achieve this, analysis of involved stakeholders was necessary, understanding of the already existing chain and how its governed so as to guide the development of interventions. Further, understanding the quantities lost at every spots, their causes and impacts would enhance decision making about food loss reduction measures.

Figure 4.Research conceptual framework



source: Authors illustration

Definition of key terms

Food losses

These are considered as all crops and livestock human edible commodity quantities that exist the chain in various ways such as discarding, incineration, deterioration, damage or other wise and do not re-enter into any other utilization such as animal feed formulation or any industrial use. However, for this study avocado food loss will be considered as that quantity or quality ofavocado that does not meet the intended value chain.

Value chain

A fully range of activities required to convey any product form conception through different phases (such as combining physical transformation, input of various services) to delivery to the final consumers and or final disposal (Kaplinsky and Morris, 2000).

Stakeholder (s)

According to Sanga *et al.,* (2013), a stakeholder is an organization, group of individuals or anindividual with interest in doings of any given project or value chain

Stakeholder Analysis

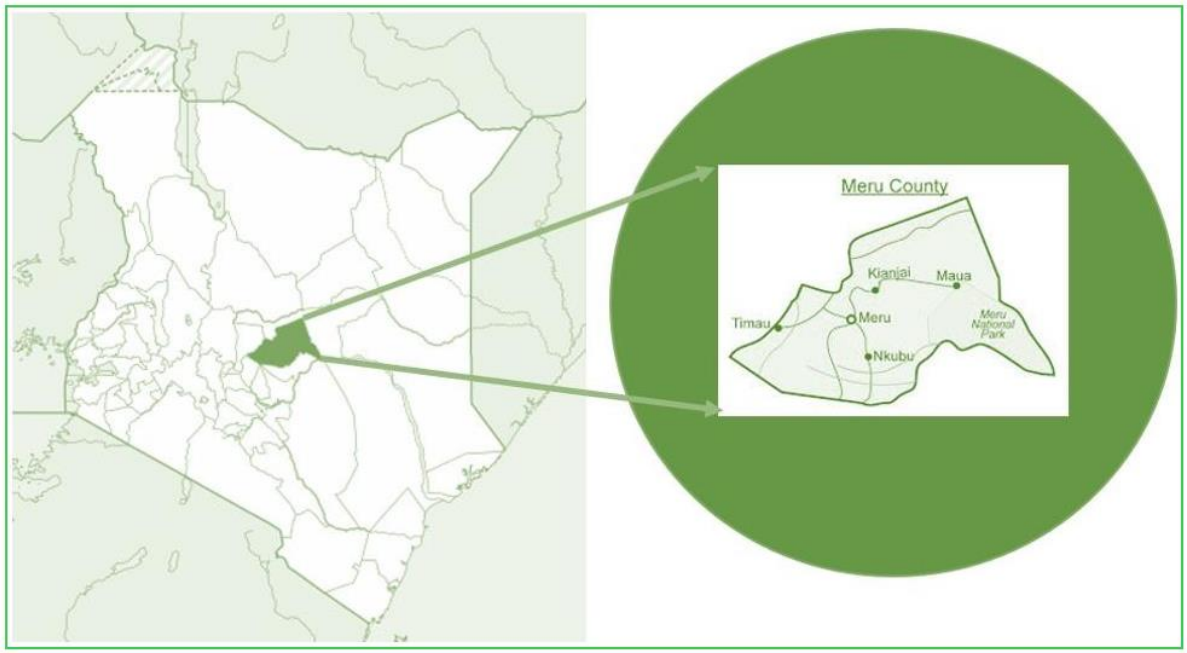
Is a process of stakeholder identification, ranking according to priority, role, power and theinfluence they have in a given chain (Sanga *et al.,*2013).

Chapter 3. Research materials and Methodologies

Information about the study area, detailed descriptions of research framework, Research approach, Research methodologies and data sources, sample size sampling, data collection tools, data processing and analysis are presented in this chapter.

3.1.Study area description.

The study was conducted in Meru county- Kenya, situated at the eastern highlands of Mt. Kenya at an elevation of about 53000 feet above sea level which is favorable for avocado production (Ominde *et al.,* 2020). The area has biannual rainfall pattern with precipitation between 853-1500 mm annually and temperature arrangesbetween 12.9 °C -25^{0}C (Muthee *et al.,* 2015). Those conducive factors together with fertile volcanic soils have facilitated the production of various crops, majorly avocado, maize, beans, potatoes, and tea (Hakizimana *et al.,* 2017). Meru county population is approximated at 1,545,714 people (KNBS, 2019) out of that, 70 % are small scale subsistence farmers (Muthee *et al.,* 2015).



Source: Ominde et al., (2020)

3.2.Research design

The research used quantitative and qualitative data collection methods. This was considered to ensure that sufficient, quality and reliable data was collected during the study. Other used strategies were desk studies for secondary data collection. While primary data was collected through case study, survey, key formant interviews, focus groups with different stakeholders and observations.

3.3 Research data collection methods

Research methods are processes, strategies or techniques that were used to collect data and evidence to answer the research questions. Mixed methods data collection methods that allowed collection of quantitative and qualitative data were used. According to Laws *et al.,* (2013) qualitative or quantitative data collection approaches

may be combined based on the data required. The combined strategies included desk studies for secondary data collection, whereas field studies and survey focus group discussion, key informant interviews and observation were used for primary data collection.

3.3.1 Secondary data collection methods

Desk studies

These studies were conducted continuously during the research period by reviewing existing literature related to food losses and food loss reduction measures. Information sources and acquisition involved use of journals and books at VHL library, peer-reviewed and E-books. Other online sources were accessed by using search engines such as google scholar, Greeni, Science direct and CABI. The studies gave background information of the study concept and justified the results that were collected

3.3.2. Primary data collection methods

Case study

This was used to collect qualitative data. The data was collected using semi- structures interviews to gather information about the study areas, the context of the existing avocado value chain, analyze involved chain stakeholders roles, food loss causes and current food loss reduction measures.

Survey

The survey approach was conducted using questionnaires which were pretested. Before administering of the questionnaires, the researcher identified and trained a research assistant who supported in the distribution, translation to the respondents who could not read or write. The questionnaires comprised of open-ended and closed-ended questions. These were administered to 40 respondents (actors in the chain) to obtain quantitative and qualitative data about socio economic status of the participants, demographic information, experience in the chain, membership to the cooperative, produced quantities, product flow as well as on food losses along the avocado value chain. Questionnaires were preferred to facilitate obtaining of information from a large group of respondents at a relatively cheaper and faster way (Laws *et al.,* 2013).

Focus group discussions

Three focus group discussions were conducted. These were guided by used of semi structure checklist. The first focus group was held with cooperative management team which consisted of 8 participants. The second focus group consisting of 12 participants was held with a mix of farmers who are members of the cooperative and non-cooperative members. The third focus group consisted of 10 participants mainly chain supporters . The data collection was on context of the chain , causes of food losses, current food loss reduction strategies, governance issues and food loss impacts (Carbon footprint). The carbon footprint was computed by summing the total amount of avocados lost along the chain then translating to the amount of carbon emitted from the observed quantities using the agricultural products Carbon emission constant as guided by studies conducted by Veronika Prošek Charvátová, (2021).

key formant interviews

Interviews were conducted with various chain actors (Farmers, brokers, processors/exporters, wholesalers retailers and supporters (KEPHIS NARIGP, KALRO**,** HCD, Avocado society of Kenya).

Checklists where to discuss key aspects of interest. Data collected from interviews included the governance structure, partnerships, product and information flow, chain relations among stakeholders, food losses incurred at every level, causes and implemented interventions.

Observations

During focus group discussions, key informant interviews and performed farm visits, observations were being caried out. Collected data was evidence about the investigated issues, socio-economic and environmental impacts of food losses, harvesting and processing center activities, documentation, handling, storage and transport facilities. Observations were also used to triangulate what was mentioned and what it reality was on ground.

3.4. Sample size and Sampling

A total of 85 respondents participated in the study. These sample size was considered to ensure good precision of the data as recommended by Laws *et al.,* (2013). The study sample for the case study was selected using stratified random sampling and all the 85 took part. The stratification was based on production areas(Meru, Abogeta, Maua, kianjai, Nkubu, Timau).

The survey participants were sampled using the convenient sampling techniques and it involved 40 respondents obtained from the total sample of 85. This method was used for sampling because respondents had other engagements and political interferences that limited their participation.

Focus group discussion participants were purposively sampled because respondents with experience and expertise on matters of the study (food losses along the avocado chain) were required (Laws *et al.,* 2013). A total of 30 from the total respondents participated in focus group discussions in three groups of with different members. Whereas for key informant interviews, 15 respondents were selected using the purposive and snowball sampling techniques.

3.5. Data reliability and validity

Pretesting of the questionnaire was conducted to ensure reliability and validity of the data. This was done by administering developed questionnaires to 20 avocado farmers in the cooperative. The gathered data was used to make necessary improvements to the final questionnaire and to give a general overview of how much time respondents would require. This was also used as one way of check if the research process was well understood.

Further, triangulation was done by comparing information collected using differenttools and observations during different sessions was done as a way of counter checking what was being mentioned and the reality on ground. To reduce challenges associated with using a third party (research assistant), the researcher assistant was trained and encouraged to be consistent by ensuring that same questions and explanations were given to all respondents.

3.6.Data processing, analysis and presentation methods

All the collected data was processed and analyzed using excel spread sheets and SPSS, package 26 respectively. Data from the case study was analyzed using, value chain analysis, stakeholder analysis, PESTEC, and SWOT. The results were presented as, maps, value chain, stakeholder matrix, PESTEC table and SWOT matrix.

Qualitative data collected from survey and focus group discussions was summarized into themes using excel sheets and further analysis was done using SPSS descriptive statistics (mean, median and mode). The results are presented using pie charts, bar graphs and tables.

The quantitative data set was subjected to KS normality test to ascertain if the data was normally distributed before further analysis. One way ANOVA was used to compare means of food loss quantities at every identified hot spot. The results are presented as bar graphs and statistical tables.

Table 1.summery of research methods used and tools

Research question	**Method use**	**Data collected**	**Tools used**	**Respondents involved**
What are the roles of the Meru avocado value chain actors and supporters?	Chain actors. Supporters, their roles and the current Enabling & disenabling factors	Desk studies survey	Semi structured interviews	85 respondents (Chain actors and support)
What is the Meru avocado value chain governance structure?	Chain robustness, reliance, reliability, chain relationships, market institutions	Survey and questionnaire And focus group discussion	Survey and questionnaire And focus group discussion	40 respondents (Chain actors and support)
What quantities are lost at different stages in the existing value chain?	Number of trees Quantities produced Quantities lost Spots of loss	survey Questionnaires Interviews	Observation Questionnaires Interviews	40 respondents (Chain actors)
What technological, institutional and economic factors are influencing food losses in the chain	Constrains, Causes Factors of influence	Focus group discussions interviews	Recording Interviews Questionnaires	85 respondents (Chain actors and support)
What are the impacts of the observed losses	Socioeconomic(livelihoods) Impact on the carbon footprint	Desk studies survey	Observations Interviews Questionnaires	85 respondents (Chain actors and support)
What strategies are currently being implemented to reduce avocado food losses along the chain?	Strategies used by different chain actors and supporters	Interviews, focus group discussion questionnaires	Observations Interviews Questionnaires	85 respondents (Chain actors and support)

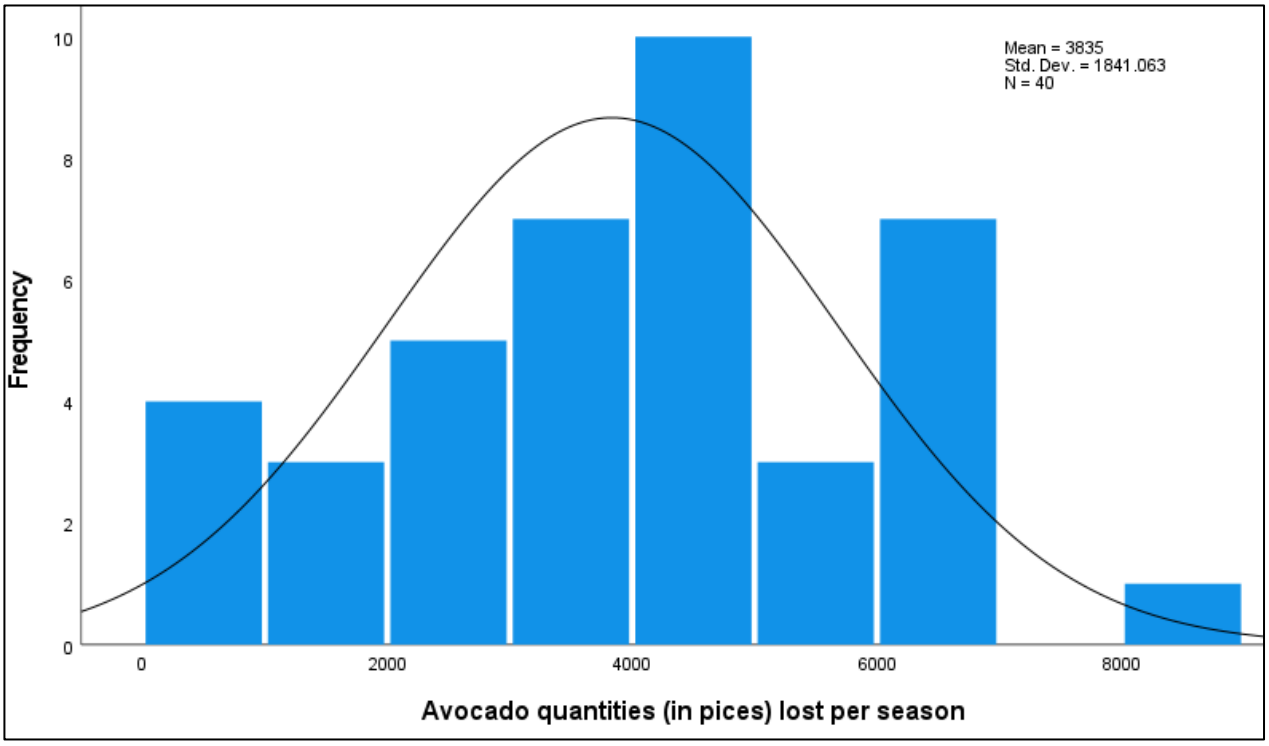
Chapter 4. Results

This section presents detailed findings from the research study, obtained from reviewed documents, key informants interviews, focus groups discussions and surveys. The results consist of general information, the analysis of the existing context of the identified Meru avocado chain, involved actors, supporters and their roles. Further, it captures the quantities of avocados lost, food loss hot spots occurrences, identified causes, currently implemented food loss reduction measures, and the identified impacts (socioeconomic and environmental-carbon footprint).

Normality test

The used data was subjected to KS normality state at confidence levels 95%. The descriptive statistics show that skewness and Kurtosis -.095 and -.453 which are close to zero and the significancy levels 0.95 was obtained. This being less than > 0.05 indicates that data was normally distributed.

Figure 5. Graph showing the distribution curve of the used data set



Source: survey data 2022

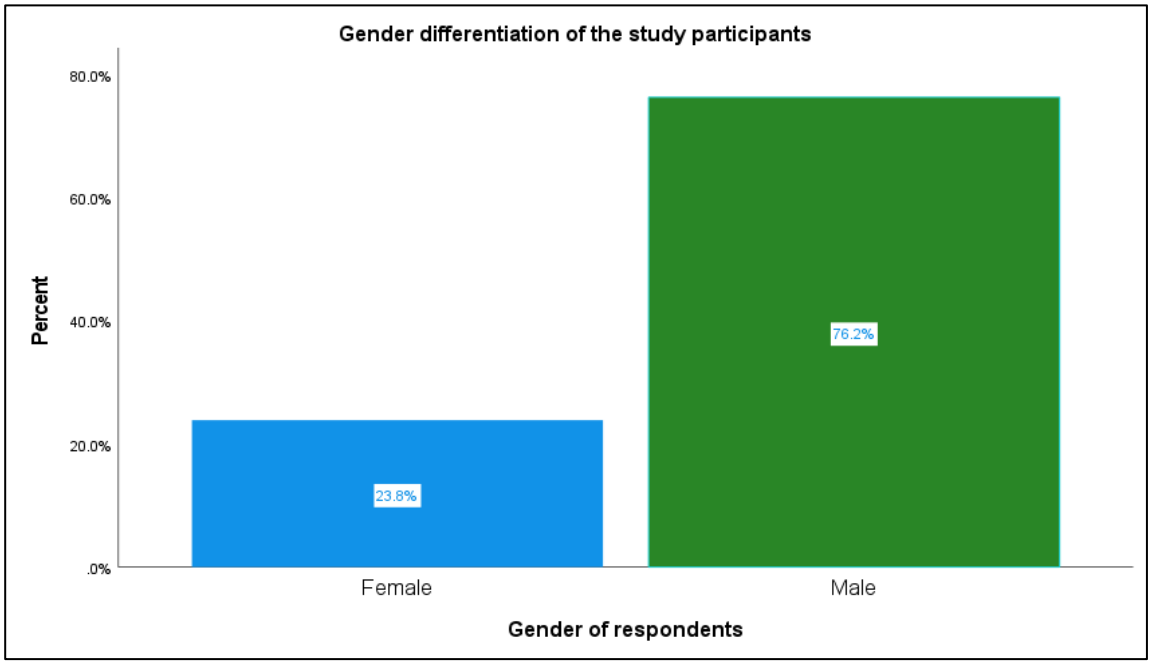
4.1. The respondents demographic information.

Eighty five (85) respondents participated in the study. These were drawn from chain actors who included input suppliers, farmers, brokers, transporters, processors, exporters, wholesalers, retailers, and chain supporters.

4.1.1. Gender differentiation of the respondents.

Indicative figures from the results show participation of both gender, though majority were male.

Figure 6. Differentiation of participants gender

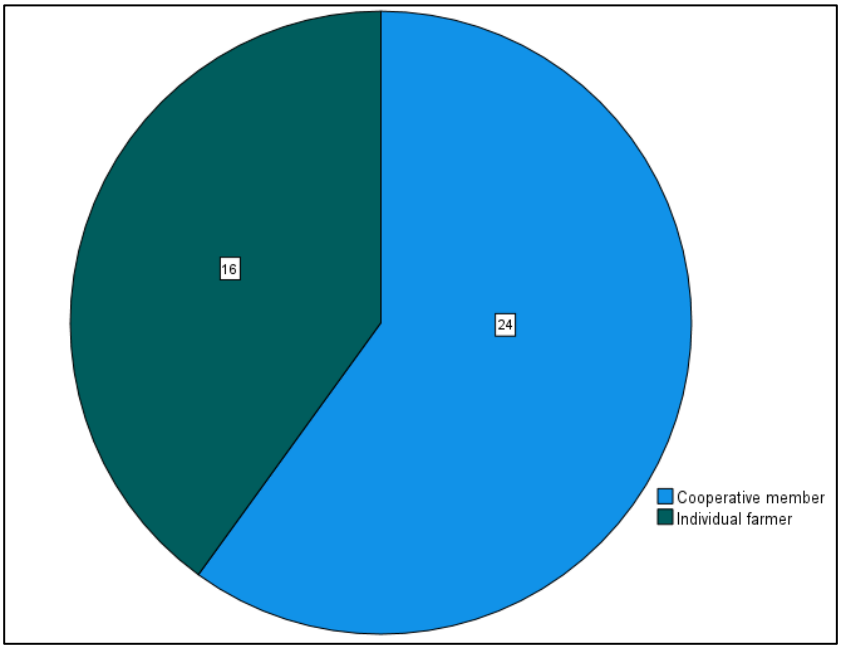


Source: survey data 2022

4.1.2. Cooperative and non-cooperative membership

The sample that was drawn from producers (farmers).40 farmers(cooperative members and non-members) of the 85 participants took part in the research study. Based on the classification, 24 of the farmers stated that they belong to Abogeta avocado cooperative while 16 worked as individuals.

Figure 7.Cooperative registered and non-cooperative registered farmers

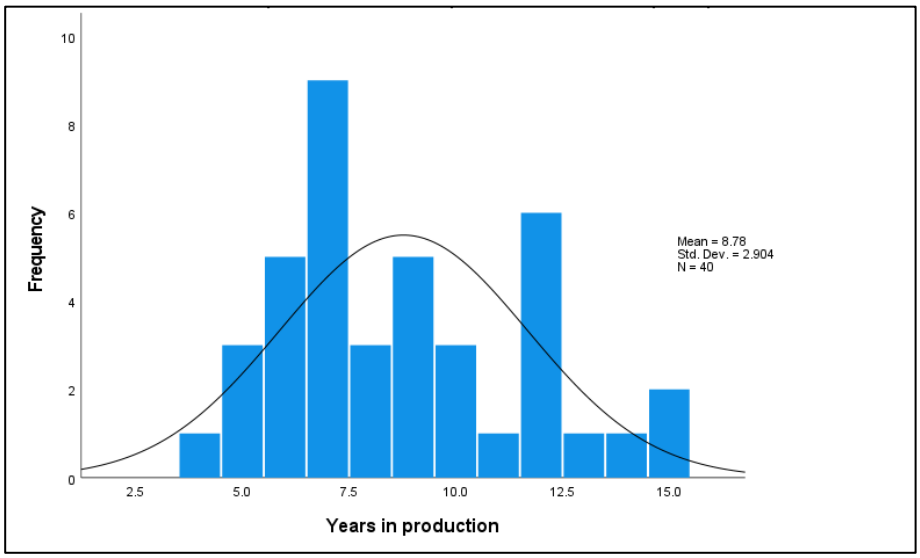


Source: survey data 2022

4.1.3. Experience in avocado farming

The farmers who participated in the study had different years of experience in avocado production and business. The survey results showed that the farmers with the list experience had four years while those with highest experience have been in production for the past fifteen years. General observation from the results indicates that majority of the participants had between seven to twelve years' experience in avocado farming and business.

Figure 8. farmers experience in avocado production

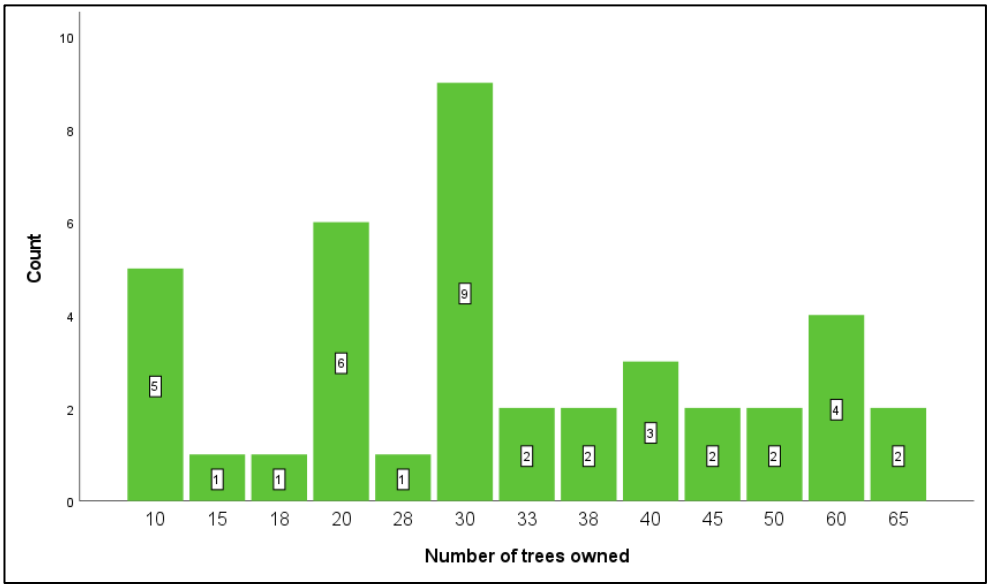


Source: survey data 2022

4.1.4. Average farm size (number of trees owned)

This was measured as the number of trees owned rather than acres because most farmers had tree scattered in fragmented plots of land and did not have records of land areas used. The results reveal that majority of the farmers owned between 20 to 30 trees.

Figure 9.Number of tress owned by farmers

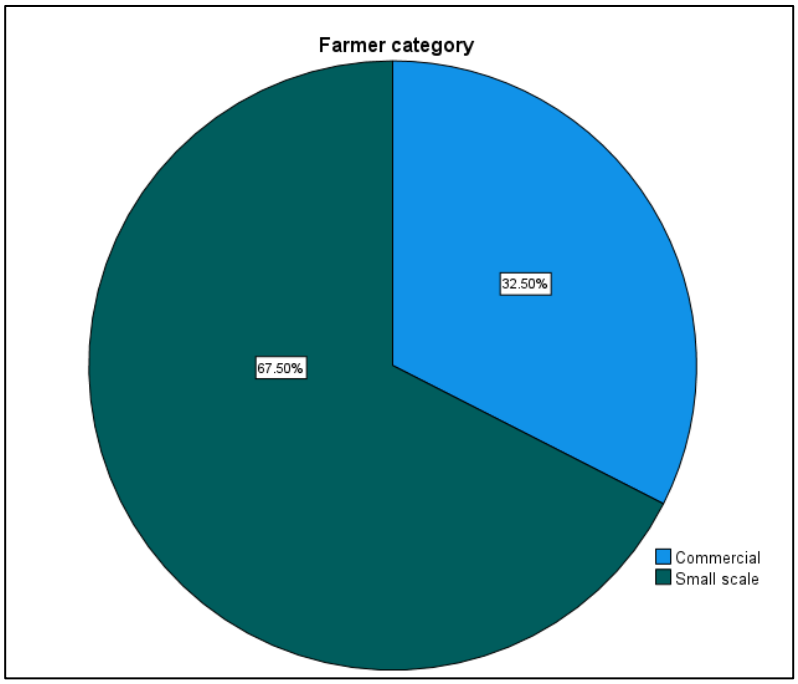


Source: survey data 2022

4.1.5. Farmer categorization (Small scale and commercial)

From the key informants and the Abogeta cooperative management team, they indicated that the avocado sector consists of small scale and commercial farmers. The number of trees was used to determine which category the farmer belongs to. Those with less than forty trees were considered as small-scale farmers while those who owned more than 40 trees were classified as commercial farmers. Results indicate that, 67.50% of the participants are small scale farmers and 32.50 constituted those practicing commercial farming.

Figure 10. Small scale and commercial avocado farmers

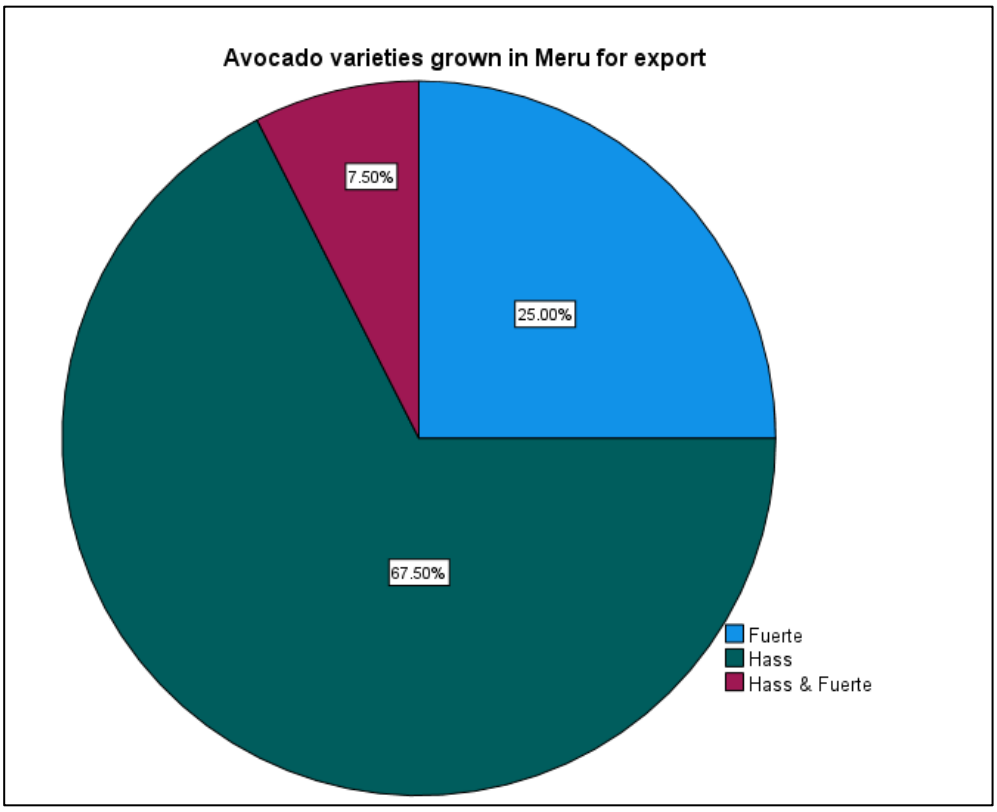


Source: Survey data 2022

4.1.6. Avocado varieties (Hass and Fuerte,)

The result indicates that majorly Hass and Fuerte avocado varieties are grown in Meru for export purposes. However, local varieties (known as 'Jumbo') are grown and they dominate the local market. From field observations, most farmers have pure stands of either Hass or Fuerte though those who have mixed plantations also exist. The survey findings indicate that 67.50% of the farmers were growing pure stands of Hass followed by 25% Fuerte and 7.50% represent those with mixed varieties of Hass and Fuerte.

Figure 11. Avocado varieties grown in Meru-county

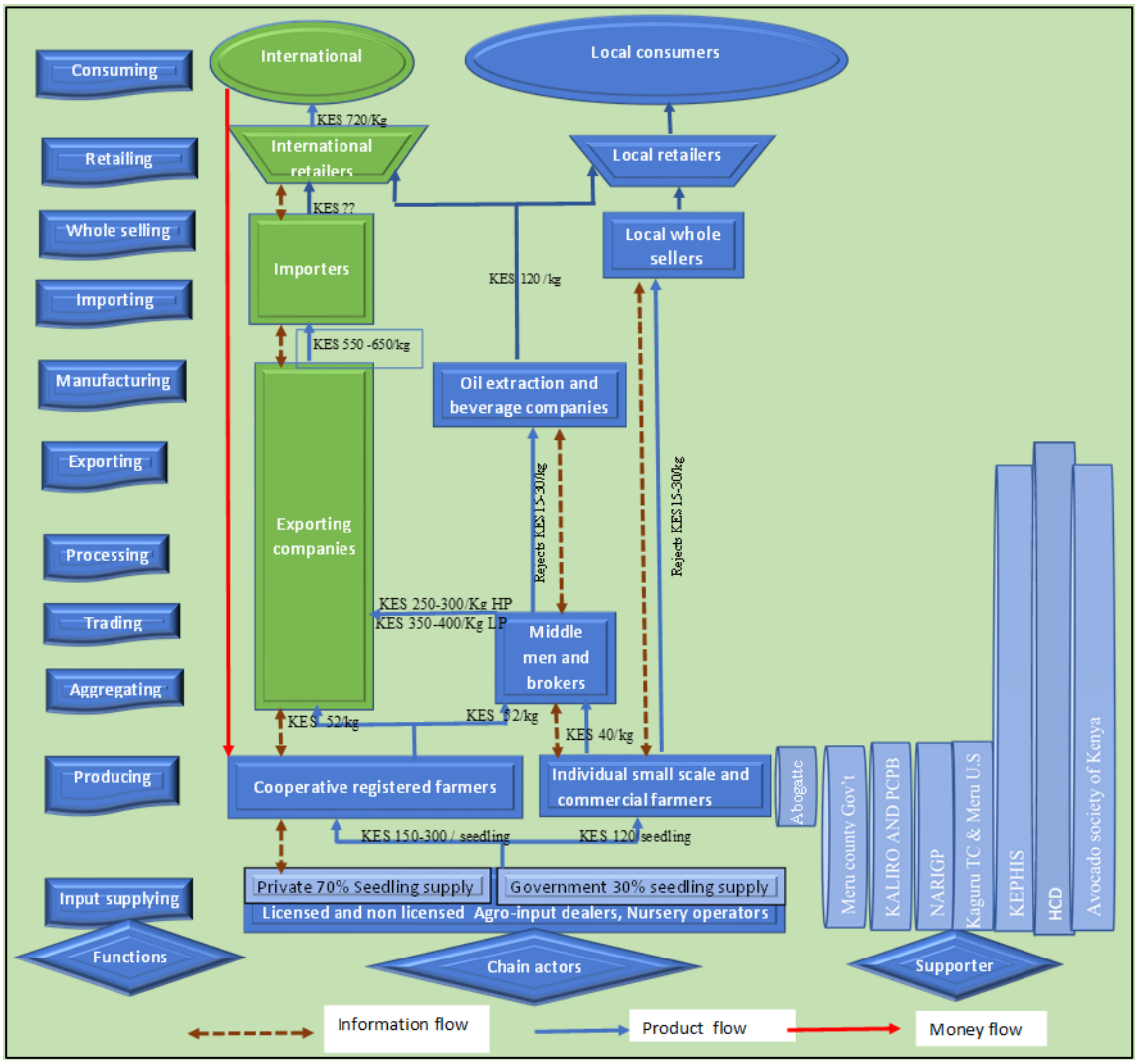


Source: Survey data 2022

4.2. Identified avocado value chain in Meru-County Kenya.

The Meru avocado value chain consist of export and local market. The export market majorly deals with Hass and Fuerte. The chain consists of different supporters and actors conducting different functions such as input supplying, producing, collecting/aggregating, processing, exporting, manufacturing, wholesaling, retailing and consuming.

Figure 12. Identified avocado value chain in Meru-county

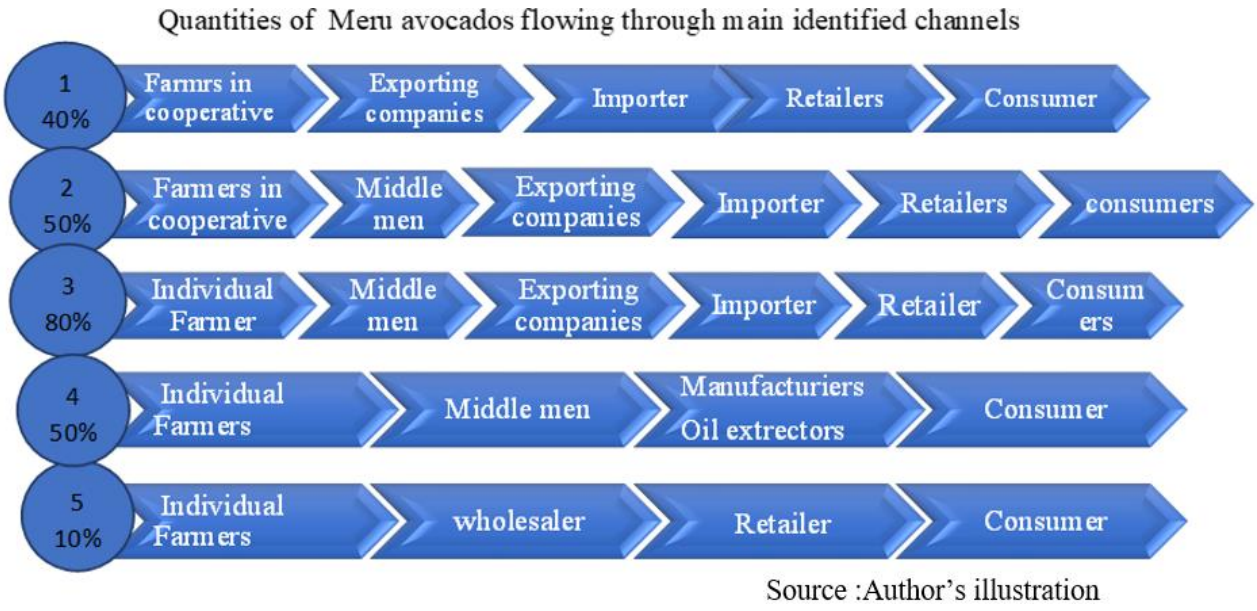


Source: survey data 2022

4.2.1. Avocado Product flow

The product from inceptions flows various channels to reach the final consumer. Case study results indicate that the Meru avocados have five major channels that they flow through. These include the formal and informal channels and quantities flowing through the identified channels vary depending on the channel and category of farmers (individual farmers and those registered as members of the cooperative)figure(13). According to finding from key informants and from the focus group discussion with farmers, they also indicated that about 10% of the total production does not exist the farm through the identified channels, neither does it get consumed at home. These quantity are left to rot and decompose within the farm.

Figure 13.Quantities and channels through which Meru avocados flow.



Source :Author's illustration

4.2.2.Avocado chain stakeholders and their roles

The study results reveals that various stakeholders are engaged in different stages of the chain. Their engagements are either formal or informal interactions along the chain. The identified stakeholders consist of actors and supporters playing various roles along the chain as described in table (2).

Table 2. Roles and responsibilities of key stakeholders in Meru avocado value chain

Supporter	Roles	Character description
Ministry of Agriculture, livestock & Fisheries	Condonation of the horticultural and food subsector	Develops, Coordinates and oversees implementation of all agricultural policies and actives in the entire country
Research institutions	Development of new technologies. Validate agricultural knowledge Disseminate innovations. Offer extension services	Kaguru Training College. Meru University of Technology. (KALRO)Research development and dissemination of agricultural technologies and innovations. Kenyan agricultural and livestock research organization.
Regulatory and legislative bodies	Develop and promote the value chain through market research. Offer technical and advisory services Regulate operations within the chain.	AFA - Agriculture and Food Authority–
	Inspection and certify agricultural input dealers Conduct diagnosis of planting material. Certify food quality and food safety for export. Offers advisory services on pest and disease management.	**KEPHIS**-Kenya Plan Health Inspectorate Service
	Registers industry dealers. Develops, Promotes and regulates sector activities. Build capacity of stakeholders. Inspect produce especially for export.	**HCD**-Horticultural Crops Directorate.

	Regulates entry, exist, manufacturing, distribution and use of products for pests control. **Fresh Produce Exporters' Association of Kenya**	**PCPB -Pest Control Products Board**
	Coordinate actors and activities in the horticulture export industry.	**FPEAK** trade Association representing service providers, growers and exporters in the horticulture industry.
Agri-finance projects	Provide financial support and other services. Provide inputs	NARIGP
Meru County government	Coordinate strategy, extension and input support for sector transformation. Implement policies and support services at county level	Has various structures of operation
Producer (farmer) organization	Organized smallholder farmers Create market linkage for their produce Lobby funds and other support form relevant authorities.	Meru has one avocado farmer cooperative "Abogatte" and has received funding from NARIGP for the construction of the pack house

Actors	Roles	Character description
Input suppliers	Access sale and distribute agricultural inputs like, seedlings, fertilizers and agrochemicals	Registered and non-registered agricultural input suppliers exist. They include nursery operators, agrochemical dealers that also provide front-line extension services to farmers especially on the usage of inputs.
Avocado producers	Source all necessary inputs and take charge of all on-farm operations and management activities. Source market linkages for their harvest either through brokers or cooperative.	Dominated by small scale farmers and to a less extent commercial focus farms. Farm operations are manual and unskilled home labor based. Majority are less organized but engage in functional interactions with majorly brokers for the sale of their produce. Those in the cooperative market their produce through the cooperative as well as with brokers.
Aggregators	Source the avocado from producers and supply to processors/ exporters Take on harvesting and preliminary post-harvest management (sorting and grading) Transport the product form farm to pack/ processing facilities.	These category consists of brokers, marketing agents and traders. (Both men and women) They are key in providing marketing channel and related services to producers. Offer advance payments to small scale farmers to facilitate their operation. They take harvesting, transportation costs. Have access to market information and negotiate product prices.
Processors	Process (sorting, washing, waxing, grading, packaging, labeling) of the produce to add value to ensure prolonged shelf life.	Commercial processing is mainly done by private companies These source large volumes from different areas Use market agents, brokers and traders.
Exporters	Most exporters do the processing (sorting, cleaning, grading, packaging, branding and transporting agricultural products to destined international markets	Own pack houses located in the outcast of Nairobi. Medium and large-scale exporters exist.. Acquire the produce from multiple locations Most of their operations are mechanized and have postharvest handling facilities such as cold storage areas. They work less closely with producers but use marketing agents, brokers and traders to aggregate required volumes. Collaborate more closely with regulatory bodies.
Wholesalers and retailers	Purchase avocado sorting, grading and trade it locally.	Dominate in the local market and majorly deal with local varieties. Less organized and their interactions with other actors along the chain are majorly informal. Wholesalers majorly purchase what is considered as rejects in bulk and sell to retailers. While retailer purchase small volumes and sell to final consumers.

4.3. Current context

4.3.1. Enabling and disabling factors

Table 3. Summary of identified enabling and disenabling factors

Factors	Enabling factors	Disabling factors
Political	Support from the county and central government and institutional support Policy and regulatory environment.	Limited extension services Less private public partnerships weak binding agreements and contracts.
Economic	Funding from partner organization	Limited Agri-financing. Inadequate capital for technology acquisition.
Sociological	Widely known and acceptable crop. Gender inclusiveness along the chain.	Limited domestic market for Hass and Fuerte. Limited connection and weak relationships between chain actors
Technological	Product handling and processing plants in some areas Existence of research institution such as KARLRO and Meru university	Poor transport and trade infrastructure Limited access to technologies. Poor food storage facilities. Inadequate innovations for improving market linkage and access.
Environmental	Favorable climatic conditions that offer two seasons (April to July and September to October).	Climatic change resulting into prolong drastic climatic conditions
Cultural	Considered as high value export crop.	Less youth engagement Land rights and acquisition. Attitude and preference Limited access and ownership of land for production.

Source :survey data 2022

4.3.2.SWOT analysis

Figure 14. SWOT analysis results for the existing avocado value chain in Meru

Source :survey data 2022

4.4.Chain governance

This study considered three aspects of chain governance, these included chain robustness, resilience and reliability. In general, the study result indicates that issues related to the governance along the entire avocado value chain are affecting food loss management, food loss reduction strategies and chain sustainability. Further, the study findings show that limited innovative support systems and institutional governance are some of the contributing factors.

Meru-avocado value chain robustness.

According to van Rijn *et al.,* (2016), chain robustness is the organized interaction between chain stakeholders to enable them overcome uncertainties along the boundaries of their transaction. These requires efficient and

trustworthy transactions among involved partners in order to reduce involved risks and costs to ensure sustainability of any given chain.

The study results from the survey reveal that several actors involved in the avocado chain do not have strong trustworthy relationships. An example of Abogate cooperative experienced burp of the signed contract by the exporting company. Secondly, according to the key informant, their tractions along the chain are just based on product sell and acquisition while after services to sustain contact do not exist.

Meru avocado value chain resilience.

Chain resilience is the capacity of the chain to resist any disruptive occurrences such as operational risks and interruptions or confront strategies to recovery from disruption. This study focuses on how involved stakeholders are prepared to deal with future uncertainties within the chain. The study finding, reveal that, the Meru avocado value chain stakeholders, support technologies and innovation are less resilient and this has a larger count on food losses along the value chain and farmer revenues. According to the key informant they hit heavy food losses during 2020 covid epidemic period because structures to mitigate shocks from uncertainties are not in place.

Meru-avocado value chain reliability.

Reliability in this study tackled regulatory structures. The avocado value chain in general has frame works that develop legislations and regulations intended to develop the sector.

The regulatory and implementing bodies are encompassed within the Horticulture Competent Authority structure, being implemented through the ministry of Agriculture and Food Authority.

The regulatory and legislative structures of importance to the horticulture sector consists of Ministry of Agriculture, HCD, KEPHIS, Agriculture and food Authority (AFA), KALRO AND Pest Control Product Board (PCPB).These develop and provide institutional structures and networks to facilitate the implementation of policies.

Key policies identified include the National horticultural policy 2012, mainly looking into development of domestic market infrastructure. Secondly the national Food Nutrition Security policy 2011 and the Agriculture Sector Development strategy 2010-2020.

However, from the survey results and key informant interviews, reveal that existing policies are not strictly implemented or monitored

4.5. Food loss occurrences

This study considered food loss as any food that leaves the intended chain before reaching the final consumer. A general occurrence was considered from production units, which consist of preharvest, harvest, post-harvest activities. The second segment was off farm which include aggregation, transportation, storage, processing, exporting and distribution to final consumers. The survey result indicate that food losses are occurring at a every stage of the chain. However, quantities lost differ at every level.

4.5.1. Quantities lost at different phases in the existing chain

Key informants categorized the occurrences as on-farm and off-farm. The general picture about food losses indicates that high food loss approximated at 33% is lost at farm level and 18% loss is estimated to occur off farm as indicated in figure (15)

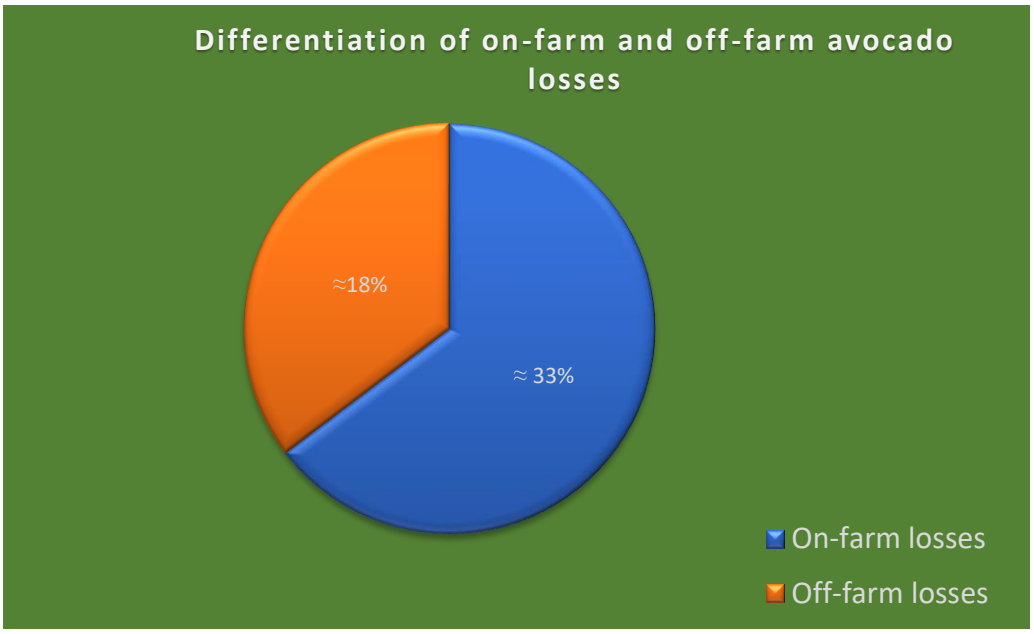
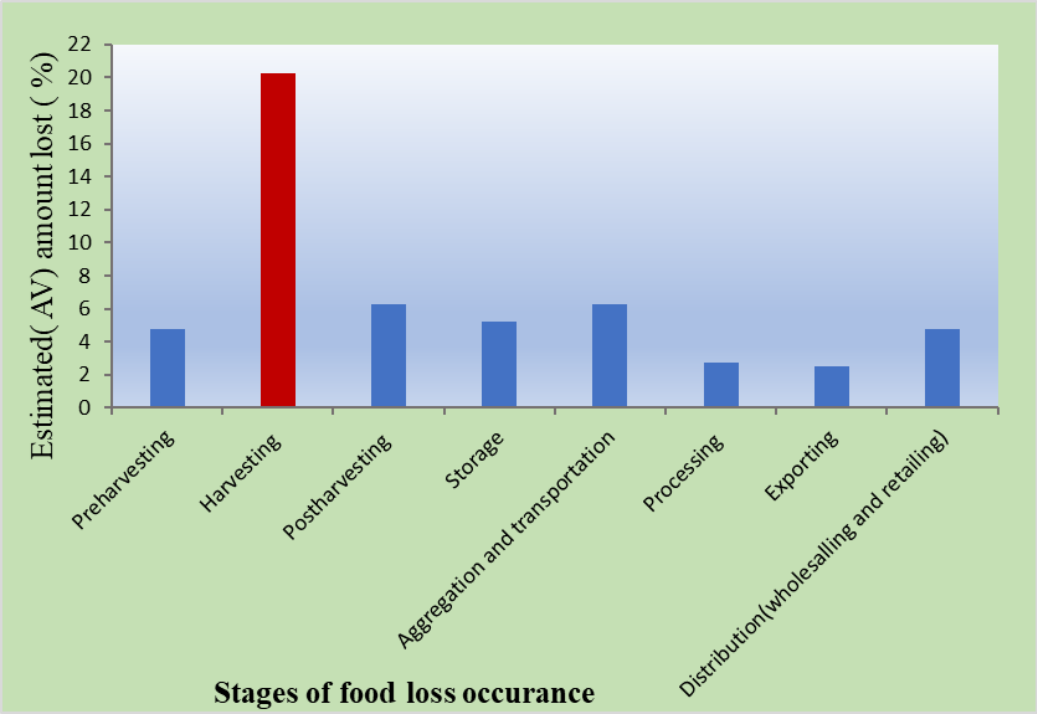


Figure 15. Differentiation of on-farm and off-farm food losses along the value chain

Further, analysis of food losses at every stage along the chain suggest average estimates that show 4.75% loss occurring before harvesting, 20 25% during harvesting, 6.25% at postharvest handling, 5.25 at storage and distribution, during aggregation and transportation 6.25 loss %loss is observed. while at processing and exporting 2.5% and 2.75% food losses are experienced respectively.

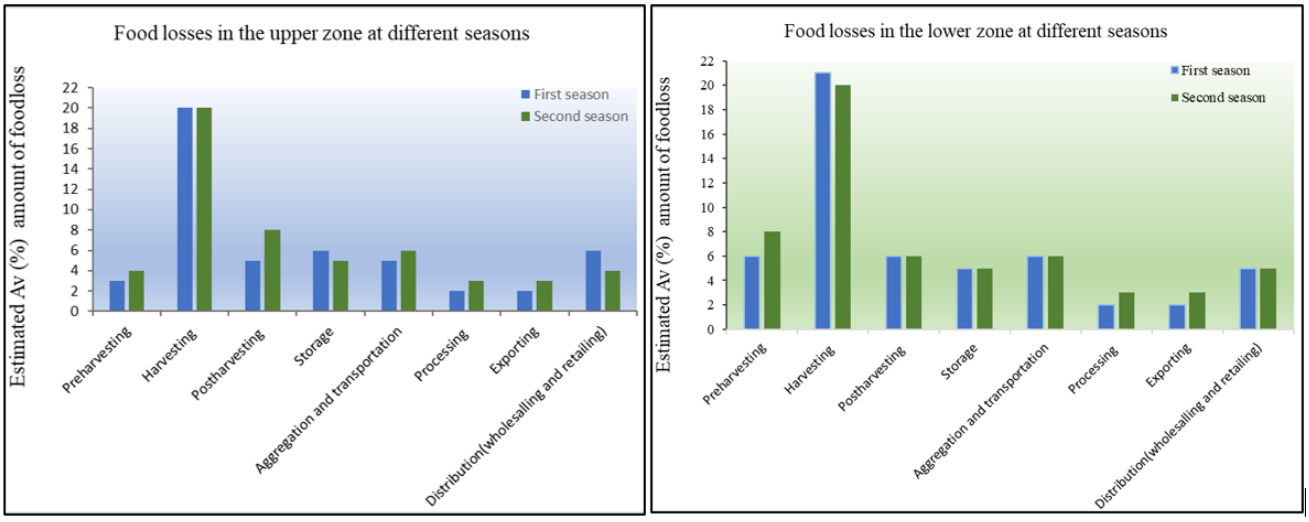
Based on the results, highest food loss is incurred during harvesting and the lowest is noted at processing as presented in figure (16)

Figure 16.Average estimates of food losses at different phases along the chain



Besides the observed trends at every stage along the chain, key informants suggest that quantities lost are also dependent on the location of production (the upper and the lower zones) and the season since two harvest periods exist (March to July for first harvest considered as the major and second from September to November). A statistical one-way ANOVA Test at confidence levels 95% reveals significant differences (<0.05) in quantities lost at preharvest levels between two harvest periods but no significant difference was noted between production zones.

Figure 17.Comparison of food loss estimates by zone and season



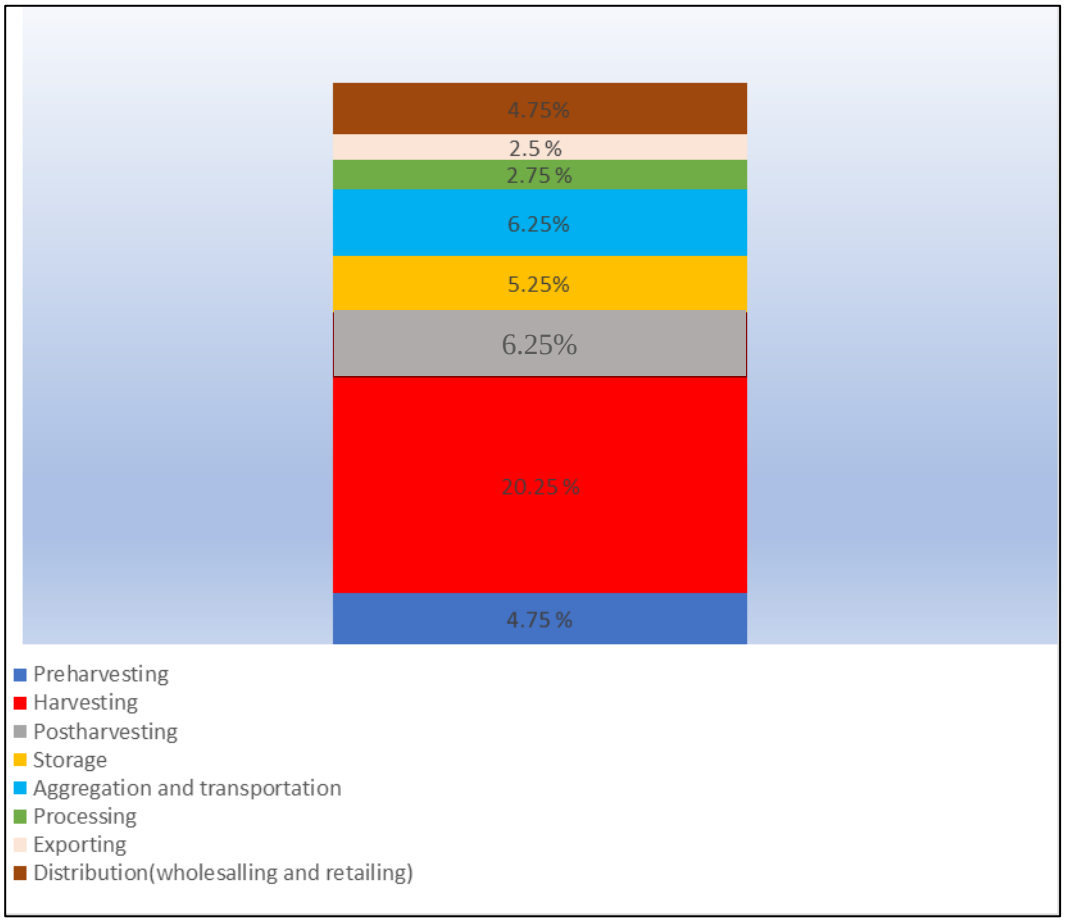
Source: survey data 2022

4.6. Food loss hot spot along the Meru avocado value chain.

The determination of food loss hot spots was bench marked with survey conducted by FAO, (2011) on food loss estimations. Similar criteria was adopted by Skoet during his study in measuring food loss and waste together with Snel *et al.,* (2021) when they conducted a food system analysis to assess opportunities for food loss reduction in Kenya.

This study assessed stages included preharvest, harvesting, postharvest processes on farm storage, aggregating, processing, exporting and distribution. Every stage that that incurred a food loss of 5% and above was considered as a hot spot. Obtained results show that food loss hotspots existing in harvesting (20.25%) followed by aggregation (6.25%), distribution(6.25%) and storage(5.25%) respectively.

Figure 18. Identified food loss hotspots along the avocado value chain of Meru



Source: Survey results

4.7. Factors influencing food losses in Meru avocado value chain.

Table 4. Summary of factors influencing food loss along the avocado value chain.

Influencing factors	Description of current state leading to food loss
Socio-economic factors	Limited domestic, regional and international market for avocados. Diverse preferences of local and international customer preferences. Low engagement of youth in the subsector especially at production. High levels of poverty among small holder farmers. Food and basic household needs deficits.
Institutional factors	Limited Policies to address food loss along the value chains. Weak implementation and adherence of existing policies Overlapping central and county government polices Weak organization among involved actors Limited organized market structures
Technological factors	Limited postharvest handling and value addition technologies Insufficient technologies to support farmers. Limited extension and advisory services Poor transport network systems. Seasonality of the crop.
Environmental factors	Climate change. Pests and diseases. Different ecological zoning

4.8. Impacts from observed food losses along the Meru avocado Value chain.

4.8.1. Social impacts.

Focus group discussions and key informants suggested that incurred food losses destabilize the food system. Secondly they suggested that observed losses have limited attainment of food security in the county. Which has impacted the attitude of small-scale farmers towards further engagement in the sector. Moreover, other stakeholders indicated that food losses affect their ability to meet necessary basic needs for their families.

4.8.2. Economic impacts

This study analyzed economic food loss impacts by considering the avocado prices from every stage and associated it to amount lost. Basing on the suggested prices by key informants, Abogate cooperative farmers earn 13KES per piece on average, one kilogram of avocado contains between 3-4 pieces depending on the size, for this study purposes and uniformity, 4 pieces will be considered make up one kilogram. That approximately earns farmers KSE 52 per kilogram. The middlemen(traders, wholesalers) sell at KSE 250 per kilogram to processors/exporters. By corresponding these variable to involved actors from inception to disposal, it implies that transactions from one actor to another for example farmer to middlemen, lost amounts cause an economic loss of KES 53/per kg to farmers this can be extrapolated to 20.25% food loss experience at harvesting. While 5.25 % during aggregation and transportation also present economic losses of KES 250 /Kg incurred by middlemen. Economic loss of averagely KES 600/kilo gram is incurred by exporters at 2.5% food loss the total purchased amount. A quick scan at supermarkets in Netherlands and other European countries, one-piece averagely costs 1.50 Euros which is equivalent to 179.13 KES and the cost of a kilo gram is approximately KES 720 which represent economic loss per kilo gram.

Table 5. Estimated economic losses from food loss along the Meru avocado value chain

	Actor	Incurred percentage loss	Accrued economic loss
Harvesting	Farmer	20.25%	53KES/Kg
Storage	Middlemen	5.25%	250KES/Kg
Aggregation and transportation		6.25%	350KES /Kg
Processing	Exporting companies	2.72%	600KES/Kg
Exporting		2.5%	
Distribution	Wholesalers and retailers	6.25%	720 KES/Kg

4.8.3. Environmental impacts.

Environmental impact of food loss was assessed by considering the amounts lost which were used to calculate the amount of carbon emitted using the carbon equivalent of avocado. The carbon footprint was computed by multiplying the amount of food lost and at given level with unit of carbon emitted by agricultural products (fruits and vegetables). This study considered an emission constant of one avocado (about 150g) emitting 0.19 kilograms of CO_2 equivalents as suggested by Veronika Prošek Charvátová, 2021). Due to unavailability of exact amounts produced in Meru, key informants suggested estimates 25 % of the country's total production. Data and reports from Statista (2022) and key informant from the avocado society of Kenya, reveal that the total

amounts of avocados produced in Kenya are estimated at 322.6 metric tons and Meru contributes 25%. This implies that the total production in Meru is approximately 80.65 metric tons.

Basing on the available figure, the carbon footprint was calculated as per the formular below

$(\sum_{afla})$ * 0.19= CO_2 kg of Equivalent ……. Eqn 1

Where $\sum_{afla}$ is Food loss amount at given stage, 0.19 is the carbon footprint from avocado

Stage of the value chain	Available amount (MT)	% Loss	Lost amount	lost amounts in kilo grammes	Carbon footprint
			(MT)	(MT*1000)	(Lost amount *0.19)
Production	80.65	31%	25.0015	25001.5	4750.285
Aggregation and transportation	55.6485	11.50%	6.399	6399	1215.81
Processing	49.2495	2.75%	1.354	1354	257.26
Exporting	47.8955	2.50%	1.182	1182	224.58
Distribution	46.7135	4.75%	2.288	2288	434.72
					6882.655

The results reveal that total amount of food lost emits 6882.655 kg of carbon equivalent. Besides the emission of carbon, food losses has impacted on biodiversity loss, extreme climatic conditions as well as soil degradation.

4.9. Current food loss reduction strategies along the Meru avocado value chain

The presented result out lines interventions and strategies implemented by some involved stakeholders at different stages of the chain.

Actors/supporters	Current strategies/intervention to reduce food losses
Producers	Organized themselves into small farmer groups and cooperative to create market linkages. Collaboration with input suppliers for acquisition of necessary inputs and services such as pesticides and extension services. Training youth in harvesting and handling of the product. Used of harvesting equipment (Only among few commercial farmers)

Aggregators	Transportation of the product in closed roof trucks (Mainly done by brokers, traders and company agents).
Processors/exporters	Use of automated equipment for various processes. Use of well-trained personal in handling and processing Established storage areas
Supporters (KEPHIS, HCD, PCPB, FPEAK, NARIGP**)**	Development of regulations Development of platforms for open discussion Offer extension services Regular inspections Certification.

Chapter 5. Discussion of results

This chapter presents discussions of the study results and further draws connotation and relevance of the discoveries.

5.1. Overview of the research findings

Avocado farming is a popular enterprise in Meru-county and other parts of Kenya. The enterprise is largely dominated by small scale farmers who are still experiencing high levels of poverty, limited land acquisition, deficit for adequate support from government and above all food losses along the value chain.

Majority of these together with commercial farmers in Meru have cultivated Hass which constituted of 65.7% followed by Fuerte that cover approximately 25%. Though according to HCD, (2015), Fuerte variety predominates the entire country, results reveal that majority of farmers have grown Hass.

This could be attributed to its vigorous growth and highly productive. To further support the findings, reports from Farm bizafrica.com indicate that Hass farmers in Kenya can earn twice better than those dealing with other varieties (Farmbiz society, 2020). Additionally, export data for 2018-2019 from KAPHIS indicate that the total export for that financial year comprised of 70% Hass against 25% Fuerte.

5.2 Identified avocado value chain in Meru-County Kenya

The study results reveal that there is an existing value chain with the product flowing through various channels. Farmers in the cooperative either sell directly to the exporters or through the middlemen. Difference in amount flowing through the two channels, i.e., 40% goes through the first channel and 50% through the second channel could be due to unreliable and untrustworthy relations between involved actors. For example, exporters delay paying or cheat the farmers. Besides, farmers lack access to timely market information to enable them in planning. Other factors could be poor living standards that increase the quest for instant payments which they get by selling through brokers rather than exporters (Isaboke and Ndirangu, 2022).

It's also observed that individual farmers sell 80% of the produce through middlemen because exporters target organized farmers who can aggregate larger quantities. According to Mwambi, *et al.,* (2016) most exporters prefer dealing with organized farmer groups to enable acquisition of larger quantities at the lowest cost.

Other reasons to support the obtained results could be associated to less organization among different actors. An example of the producers, most of them are reluctant to join the cooperative and this limits their access to direct market linkages (Amare *et al.,* 2019).

Further, inadequate market structures to support development of business agreements that offer an assurance for the market could be contributing to the observed results.

The chain stakeholders

The chain constitutes of government, private and individual stakeholders taking part as chain actors or supporters. According to kit *et al.,* (2006), chain supporters are individuals, companies or organizations that directly or indirectly provide arrange of services such as financial and non-financial support, advisory services,

legal matters among others, to chain actors to increase competitiveness and efficiency in any given value chain. The engagement of involved stakeholders could because, the crop has attracted international market (Gyau, *et al.,* 2016).

Further, the technical support and engagement of various stakeholder in the subsector is attributed to the high value earned from avocado compared to other horticultural crops (Muthomi, 2019). Besides, this being considered as ahigh value crop, government involve might been to develop the sector and consider production of avocado among small holder farmers as strategic for poverty alleviation.(Amare *et al.,* 2019).

5.3. Current context of the chain

The results reveal that the current operations along the chain have been enabled by political, economic, social, technical, environmental and cultural factors.

Politically the sector has received attention and support from central and county governments that have developed policies and funded the sector in support of the development of the chain. More pronounced is the government involvement which has enabled the country to secure international trade relationships (Snel, *et al.,* 2021) . For example, agreements with China were recently signed to supply frozen avocados as sighted by the key informant at HCD. Further evidence of NARIGP and other government projects setting aside funds to support various activities like establishment of the pack house by Abogeta avocado farmers' cooperative (Mwaniki and Nyamu, 2022). These engagement have been encouraged because the crop is socially accepted and regarded as ahigh value crop which has attracted participation of both women and men (Wasilwa, *et al.,* 2004). Continuous research by relevant authorities KALRO are facilitating the development of new technologies that may enhance food loss reduction (Farmbiz society, 2020) and (Snel, *et al.,* 2021).

However, more attention should be put to facilitate improvement of extension services, support to small scale farmers who constitute 70% of the producers. Karing'u *et al*., (2020) suggests that limited funding and support to small scale farmers hinders their participation and weaken chain relationships among actors, thus limiting development of strong engagements that ensure sustainability. Further, poor/limited extension services result into limited levers for collaboration, distorted market information, weak farmer organizations, limited access to scientific knowledge which results into increased chances of food losses (Mwambi *et al.,* 2016).

Though Wasilwa, *et al.,* (2004) and Farmbiz society (2020) recognized the contribution of technology development in the sector, it's important to acknowledge that poor road network and transport facilities still pose a challenge to movement of the product from production units. These poor systems lead to delays that result into product deterioration since avocados are perishable (Moïsé, *et al.,* 2013).

Further, technologies to mitigate effects of climate change have not been put in place, yet currently due to climate change, Kenyan farmers are experiencing introduction and regular occurrence of pests like

False Codling Moth, fruit flies and diseases that are increasing food losses (Odong, 2022).

Besides the above weaknesses, the sector is threatened by changing trade barriers, low farm gate prices that

limit competitiveness and weak mechanisms to support commitments and traceability (Wasilwa *et al*.,2004).

5.4. Factors influencing food losses in Meru avocado value chain

The study identified various issues causing food losses along the avocado value chain in Meru. The identified factors were categorized as socio-economic, institutional, technological and environmental.

5.4.1.Socioeconomic factors

From the results, key socioeconomic factors include limited domestic market and diverse customer preferences. Hass and Fuerte are regarded as export varieties (Kathula, 2021) and their prices in the local market are higher than the local varieties. Despite the high nutritive value attributed to Hass and Fuerte, its choice of outlet is out competed by local varieties in the domestic market (Isaboke and Ndirangu, 2022). This implies that the surplus from the export chain goes to waste.

Secondly there is less engagement of youth in the subsector. These has left elderly persons to predominate production and marketing of the product. The observed trend is as a result of high levels of poverty against the length period required before gaining returns. Besides land acquisition for production of perennial crops remains a big challenge to the youth (Van Uffelen *et al.,* 2022).

5.4.2.Institutional factors

From the institutional point, though policies exists to regulate various activities within the chain, these have received weak attention toward their implementation (Wasilwa, *et al.,* 2004). Further, overlap between county and central government policies leaves the involve stakeholders confused about which one to adhere to. Additionally, market structures like price determination, information flow and physical structures have not been put in place (Mati *et al.,* 2022). These in the long ran have resulted into weak organization among actors (Gstraunthaler, 2010)

Technologically the sector has inadequate technologies to support the farmers in post- harvest handling and processing of the product to reduce deterioration since this is a perishable product. This coupled with limited extension services, poor road networks have led to high food losses especially during pick production seasons. According to Bustos and Moors, (2018), Reducing post-harvest food losses requires collaborative innovation.

5.4.3.Environmental factors

These include climatic change which has resulted into extreme weather conditions such as prolonged drought periods that affect the quality of avocados (Wasilwa *et al.,* 2004). Moreover, in the recent years it has been noted that, introduction and regular occurrence of pests and diseases has increased(Moïsé, *et al .,*2013). Yet government has not put in place risk management strategies.

5.5.Food loss hot spots along the Meru avocado value chain

Harvesting

Basing on the study results on the food loss hot spots, harvesting stage has been identified as the number one food loss hot spot. This could be attributed to poor harvesting techniques, use of unskilled labor, and inadequate

knowledge on market requirements. Majorly small-scale farmer, brokers or traders use manual unskilled labor. These category has minimal knowledge on harvesting methods, size requirement and maturity detection. Ramírez-Gil *et al.,* (2019) in their study on the causes of Hass avocado rejection proposed that use of manual unskilled labor increased food losses at harvesting. They farther suggested that key critical losses occur from lenticel damage, breakages of dropping of unintended fruits, sunburns, malformation, manifestation of pests and diseases that most harvesters are not able to recognize.

Aggregation and transportation

Most avocados are sourced from small scale farmers who do not have a central collection point. Freshly harvested fruits are aggregated from farmer to farmer. The fruits are packed in bulk and transported in open trucks (non-refrigerated) through rough roads. Those conditions subject the fruits, mechanical damages, bruises and deterioration due to heat. The observed results are similar to Snel *et al.,* (2021) observations in the mango subsector of Kenya.

Distribution

This is mainly taken on by traders and wholesalers as they bring the product to the retailers or institutional consumers. They lack storage and cooling facilities where the fruits can be kept as the await distribution. The products are kept in the open trucks or sacks, exposing them to harsh weather conditions, Resultingly the fruits get sun burns, mechanical damages and reduction in shelf life (Ramírez-Gil *et al.,* 2019).

Storage

Most farmers, traders and middlemen do not have storage facilities to mitigate risks of product deterioration and spoilage. On farm, harvested fruits are kept on ground under trees (picture U) or old buildings (picture V), exposing the products to contamination and unfavorable climatic conditions such as high temperature (Picture W). Temperature is a critical aspect that plays a role in the product shelf life. According to Mwaniki and Nyamu, (2022), observed food losses are as a result of inability of small-scale farmers or government to invest in the development of infrastructure such as storage facilities.

Picture (i) Avocado postharvest handling and storage methods practices by some farmers

5.6. Impacts of the observed food losses along the Meru avocado value chain

Food losses along the avocado value chain is affecting all involved stakeholders. The losses cause considerable social, economic and environmental impacts(Willersinn *et al.,* 2017). The percentage food losses at every level translates to a setback in expected monitory income(economic loss) to the involved actor. A general comparison among all involved actors indicates that farmers are highly economically impacted since most losses are occurring at farm levels, yet they receive the lowest farmgate prices. Moreover, accumulative food losses directly impact on the country's Gross Domestic Profit (GDP). Avocado production is resource extensive and imposes significate pressure on the environment (Watson 2009), Moreover, the amounts lost have a remarkable carbon footprint (Qin and Horvath, 2020). The observed carbon footprint result of 6882.655kg carbon equivalent from this study is similar to what was obtained by Willersinn *et al.,* 2017 and Read *et al.,* 2020).

5.7. Current food loss reduction strategies along the Meru avocado value chain

The producers. (Smallholder and commercial farmers)

Some of the key causes of on-farm food losses include limited access to extension services that has resulted in poor farm management especially on pests and disease control. According to the key informants and results from Wasilwa *et al.,* (2004),both pointed out that country has limited extension workers, the available staff can only offer services to organized groups upon demand.

The currently, strategy of farmers organizing themselves to a cooperative association to demand for services is yielding positive results because organized farmer cooperative or associations have a higher bargaining power compared to individual. Secondly it's easy to reach and deal with groups of farmers with the limited resources and engage in agreements (Mwaniki and Nyamu, 2022).

Besides pests and diseases, farmers lose a lot at harvesting and the current strategy used by the cooperative is training youth in harvesting techniques as demonstrated in picture (i).

However, the adoptability and youth engagement is very low due to the quest for quick income that has pushed most youth to urban areas.

Picture (ii).Participants demonstrating on the avocado harvesting to reduce food losses

Storage at farm level

Though most processing companies have well equipped storage facilities, the initial stages of the chain still experience a big challenge it storage of the product. Temperature being critical in product shelf life, it requires proper storage facilities at all stages to avoid continual of effect that could occur in the earlier stages of the chain.

Aggregation and transportation

Though some exporting companies use closed roofed trucks and wooden crates to transport the products form production areas to processing centers. These are not sufficient to cover the total area, besides they still experience food losses due to long distances through poor roads, uncontrolled temperature and bruises. Additionally, a bigger challenge to meet minimum avocado transport requirement still lags behind among the brokers (picture iii T) because they do not have central areas as collection points yet they deal majorly with small scale farmers scattered in various parts of the county. According to Karing'u, *et al*.,(2020), less organized small holder farmers have limited access to central market structures or platforms. This pushes them to deal with middlemen who reduce their transaction costs by picking up the produce from their location (Amare*, et al .,* 2019). As seen in Picture (**iii S)**.

Picture (iii) Avocado aggregation and transportation in Meru

Processors/ exporters

Most processing companies do the exportation of the product and one of the key strategies to reduce food loss along the chain is continuous training of their field on the appropriate handling of the product (Bustos and Moors., 2018). Besides that, companies have established well automated processing centers with equipment and facilities to reduce contamination, minimize effect of temperature and easy handling through appropriate packaging (Affognon, *et al.,* 2014)**.** However, these system can only detect some extrinsic attributes of the product and skilled manpower is required to conduct manual processes such as sorting

Picture (iv). Avocado processing

Supporters

Development of regulation by Ministry of Agriculture, livestock and fisheries. Among the key regulations developed include-

Yearly declaration of opening harvesting period for Fuerte and Hass variety for export(for 2022 Fuerte 4th March and Hass variety on 18th March)

Requirement for all avocado harvesting and handling processing to conform to the crops (horticulture crops) regulations 2020-part iii paragraph 18 and KS1758.

Transportation of avocado sshould conform to the crops (horticulture crops) regulations, 2020-part iii paragraph. According to studies conducted by Totobesola *et al*., (2022), key strategies to food loss reduction is the development of holistic approaches and polices

Secondly government through world bank project is funding different aspects along the chain, for example, Abogeta avocado farmers' cooperative has been funded through NARIGP to construction a pack house at Abrogatte west.

Chapter 6. Conclusions

6.1. The value chain and stakeholder roles of the Meru avocado value

The study looked at reduction of food losses along the Meru-county avocado value chain in Kenya. Based on the reviewed documents, results from focus group discussions, key informant interviews and survey, conclusions are drawn that, there is an existing avocado value chain with both formal and informal channels. The chain deals with majorly Fuerte and Hass avocados for export and local varieties are majorly for domestic market. Involved stakeholders play different roles to develop and sustain value chain activities as chain actors or supporters and the study recognizes government as being the main supporter.

It is evident that stakeholders have wide-range of roles and have high potential to influence the development of food loss reduction measures to meet the international demand. However, policy strengthening and stronger collaborations for better resource mobilization is required.

6.2. The Meru avocado value chain governance structure

The chain has existing governance structures, though weak chain relations among actors turn out as a major hinderance to the smooth flow of the products and market information. Further, the chain resilience in terms of capacity to overcome or resist disruptive occurrences for example from climate change have not been instituted. Reliability of the chain in terms of regulation and legislations has been tackled by government however, less attention has been offered toward their implementation.

6.3. Quantification of food loss at different stages in the existing value chain

Food losses were investigated along eight stages of the chain, preharvest, harvest, postharvest storage, aggregation and transportation, processing exporting and distribution. Food losses are occurring at every stage but more pronounced (hot spots) are at harvesting which contributes the highest amount of 20.25% food losses due to poor harvesting techniques and inadequate knowledge among harvesters . This is followed by aggregation, transportation and distribution that are contributing to 6.26% food losses due to inappropriate transportation facilities. Storage as another key hotspot contributing 5.25% food losses due to poor or lack of storage facilities especially among farmers and aggregators .

6.4. Factors influencing food losses in avocado value chain

The study identified various factors influencing food losses along the chain as environmental, Socio economic, technological and institutional. From the focus group discussions, key informant interviews and the researcher's perspective, it has emerged that the major constrains influencing food losses or hindering food loss reduction along Meru value chain are inadequate appropriate technologies for handling the products especially among farmers and aggregators. Secondly, weak institutional structures such as poor organization among involved actors, which has impacted the chain relations and trust among actors. Besides those previous factors, another critical issue is the weak policy implementation and inadequate governance structures for monitoring and reinforcement of the existing regulations.

6.5 Impacts of the observed food losses

In a complex linkage of moving food products from producers to consumers, huge amounts are lost. The lost amounts increase inefficiency of the resources since high inputs are used for production. Besides high input use, lost mount increasingly exert pressure on the environment through greenhouse gas emissions. The food loss amount observed in Meru are contributing significate amounts of carbon footprint approximated at 6882.655kg of carbon equivalent.

6.6 Currently implemented strategies to reduce avocado food losses along the chain

Basing on the research results, currently implemented food loss reduction strategies are supportive in reducing food losses along the value chain. Training of youth to carryout harvesting and continuous training of farmers is important. However, more incentives should be planned for, to motivate youth engagement in the sector. Additionally, continuous training and sensitization on minimum handling and transportation should be planned for by the relevant authorities. Finally, development of policies is a great idea but more effort are required from policy implementors to ensure better understanding and adherence to by most chain actors remains achallenge.

Chapter 7.Recommendations and interventions

From the research results and conclusions, the possible areas for interventions have been identified to reduce food losses along Meru avocado value chain. This may ensure sustainability and profitability among involved actors especially the small-scale farmers. The recommendations are mainly to the cooperative, major supporters(Kenyan government) and SIA project for food waste reduction and food quality living lab. Other recommendations are also suggested for other involved stakeholders.

Chain stakeholders

i) Chain actors

Generally, all stakeholders should consider chain upgrading through vertical and horizontal integration. Individual producers specifically should organize themselves into formal producer groups and engage in contractual farming with exporters and manufacturers. In this way, they are able to integrate and perform various activities such as harvesting, aggregation sorting and grading to reduce food losses incurred during prolonged product movement through various actors. It also increases profitability because farmers are able to harvest the required quality that meets the market. Further, sorting and grading at farm level will facilitate better negotiations for higher prices since different grades(12,14,16,18 and 22) have different prices. Horizontal integration can be developed through strengthening of relationships among stakeholders and governance structures. This can be done through collaboration, use of existing avocado platforms such as avocado farmers' association of Kenya, and continuous sensitization. This will enhance stakeholder inter-coordination, market information sharing and combining resources to develop structures for food loss reduction.

ii) The chain supporters

The government through Ministry of Agriculture, Fisheries and Livestock should consider strengthening the implementation of the existing policies through continuous capacity building of involve stakeholders and set up monitoring and evaluation mechanisms. Further, since there is a bigger out-cry on the shortage of extension workers, development of new innovation such as improved IT services and apps specially for sharing agricultural information, will enhance easy access to information by stakeholders. Moreover, linkages between actors would be strengthen because more important information can be shared to many stakeholders within a short period of time.

Strengthening of the public-private relations with interested projects like SIA and others by leveraging private sector financing to support technology development, incentivizing investment for avocado handling and processing and encourage private technical or business extension services. This will enhance development of food loss reduction measures, competitiveness and economic growth.

The Abogeta avocado farmers' cooperative

According to reports from the key informants, the cooperative has received funding for constructing a pack house. The spearheading team and the management of the cooperative should ensure that the establishment

and operationalization of the pack house should be achieved within the next 2 years. This can be achieved through collaborative planning, development of the guidelines and commitment to achieving them within the set period. This will enhance reduction of food losses associated to poor storage and poor transport facilities.

Secondly, the cooperative should work toward building more private-public collaborations through coordination, accountability and transparency to enhance trust building among stakeholders and further source funding and appropriate technology for intended processes to enhance food loss reduction.

The third recommendation to the cooperative is to strengthen internal capacity and promote the development of stronger governance structures through capacity building. These will improve market information access, analysis and dissemination. Further, these will promote production based on the market requirements and it will offer the cooperative higher bargaining power.

Other stakeholders (brokers, middlemen, manufacturers, wholesalers and retailers)

These category of stake holders are encouraged to join or formulate formal associations. This can be achieved by consulting relevant authorities on the necessary steps, and or collaborating with already established associations to guide the development of stronger associations. This will facilitate collective market access and advocacy, the development of clear chain segments, division of activities, extension service delivery and collaboration for better exploitation of the existing opportunities within the sector.

The commissioner -SIA

SIA is interested in the business-to-business approach through Food waste Reduction and Food Quality living Lab(FORQLAB). The project should develop partnerships with Abogeta avocado farmers' cooperative, with the aim of chain upgrading through improvement of harvesting, postharvest handling and storage aspects.

Abogeta is suggested because it's one of the well-known established farmer cooperative and has currently received funding through NARIGP for the establishment of packhouse, but they may require more financial and technological support. Secondly, the suggested segments of the chain are critical food loss hotspots. The suggested partnership can be established by the two parties involving in different roles toward chain upgrading. Abogeta avocado farmers' cooperative takes lead in the establishment of the packhouse, reorganizing the governance structures, mobilization of new farmer members in order to produce required capacities and linkages for chain upgrading.

While SIA through the FOQLAB project will provide both technical and financial support. Technical assistance in the development of business plan, training in marketing of their product and facilitation for the development of new technologies for harvesting, post-harvest handling and storage to ensure quality control at production levels. Further, FOQLAB being European based, should support in creating market and other linkages internationally by collaborating with sectors with a similar business idea.

To ensure sustainability of the partnership and intended business model, the cooperative develops operational agreements with SIA but, the shareholders are farmers of Abogeta avocado cooperative. These members will

be required to pay an agreed annual percentage of their gross sale to the cooperative to facilitate necessary operations and the earned annual profits should be redistributed to all members

The anticipated partnership/ business model outcomes will be the reorganized, strengthened Abogeta governance structure and increased small holder farmers membership.

Secondly, improved avocado quality and an upgraded value chain through vertical and horizontal integration that will enhance food loss reduction and improved profits among the small holder farmers.

Suggested upgraded value chain with vertical and horizontal integration.

Figure 19 proposed Meru avocado value chain

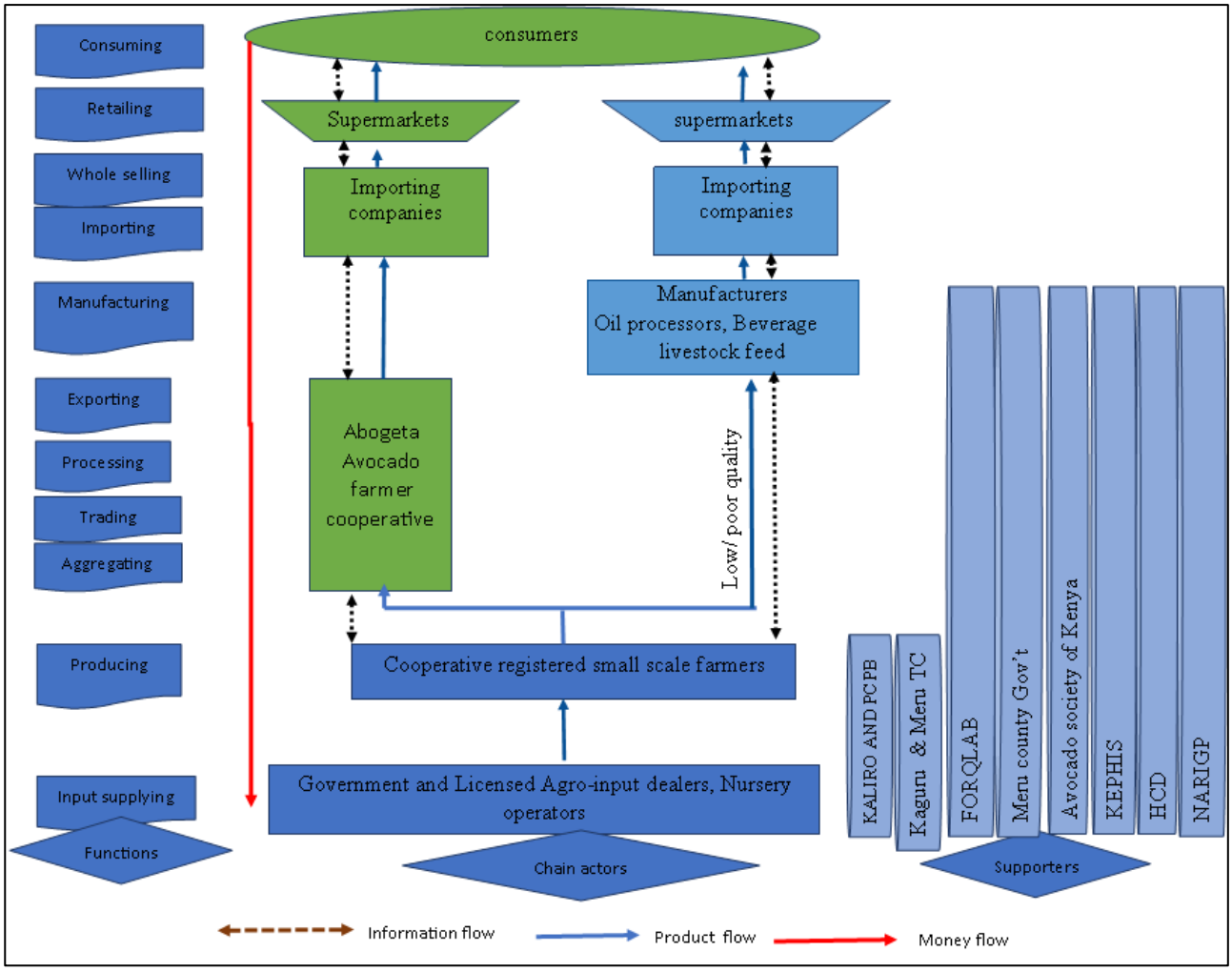
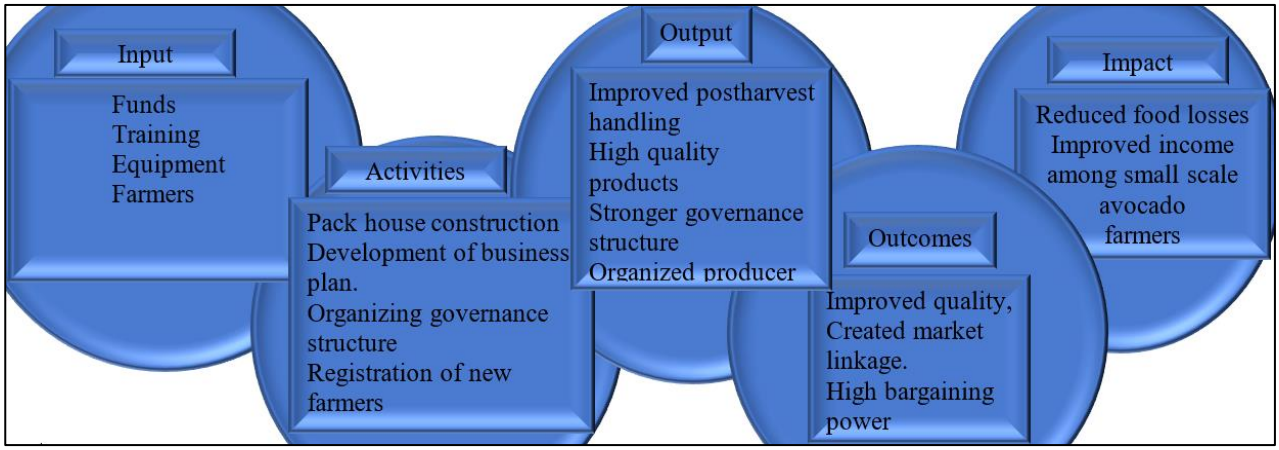


Figure 20. Impact of the new chain when upgraded



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Annexes

Annex 1. Research schedule.

Planned Activities	Implementation timeline in Months and weeks																		
	May		June				July				August				September				
	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	
Desk studies, proposal development																			
Proposal submission																			
Proposal pitching																			
Data collection planning																			
Interview with stakeholders																			
Focus group discussions																			
Questionnaire distribution																			
Data process																			
Data analysis																			
Thesis writing																			
Thesis submission																			
Final defense & graduation																			

Annex 2 Questionnaire

Research questions

Dear respondent

I am master students at Van Hall Larenstein University of Applied Sciences studying agricultural Production Chain Management and currently am attached to the FORQLAB Project conjointly spearheaded by Four universities (VHL, AEREES University of Applied sciences, HAS, Inholland, Meru and Egerton universities). Am conducting research on Reduction of Food loss along Meru avocado value chain in central Kenya. I request for your cooperation to offer appreciate feedback to the following questions. Answering of the questions will take about 10 to 15 minutes. All information and feedback will be treated with high confidentially and will be used specifically for research purposes.

1. Are you a commercial or small scall avocado grower

Commercial ☐

Small scall ☐

2. What varieties of avocado are you growing

i) Hass

ii) Fuerte

iii) Others (Name)……

3.Where did you get the seedlings from

Government, ☐ licensed nursery operator ☐

Non licensed nursery operator ☐ other farmers ☐ own seedlings ☐

4.How much do you buy a seeding…….

5. How many mature avocado trees do have…….

6.How old are your trees ……

7 .How long have you been in avocado farming…….

9. Are you a member of any cooperative or farmer group for avocado

Yes ☐ Name the cooperative…… No ☐

10. How many pieces of avocados do you harvest per tree per season

100 – 200 ☐ 201-300, ☐ 301-400, ☐ 401-500 ☐ 502-600 ☐ 601-700 ☐ 701-800 ☐

801-900 ☐ 901-1000 ☐ 100 above ☐

11. Do you sell your produce through a registered avocado cooperative?

i) Yes (if yes, name it and proceed to Question 7 and 8)……

(ii) No (if no proceed to Question 8)

12. What quantity do you sell to the named cooperative

……..

13. What other channels do you sell your avocado

……

……. …….

14. How much do you lose every season

100 – 200 ☐ 201-300, ☐ 301-400, ☐ 401-500 ☐ 502-600 ☐ 601-700 ☐ 701-800 ☐

801-900 ☐ 901-1000 ☐ 100 above ☐

i) Approximate in % ……

15.What causes you lose the mentioned amount

……

……..

16.What are you currently doing reduce the occurrence of the losses

……..

……

17. what is social impact of the avocado production in your view

……. ……

……

18.What economic impact are you experience from avocado food loses

……..

……..

19. How do you get market information about the avocado

……

……

20. Do you get any support for your activities as a small scall farmer

Yes ☐ what type…… Name the giver ……

No ☐

21. What is your relationships with other chain actors (middlemen, exporters, processors)

Very p☐r Poor ☐ Go☐ very good ☐

22.What is your gender

Female ☐ Male ☐

Part two

Other actors

1.What is your role in the avocado value chain

Company agent ☐

Middleman/women ☐

Harvester ☐

Transporter ☐

Processor ☐

exporter ☐

manufacturers ☐

wholesaler ☐

Retailer ☐

2. Where do you source your avocado from

Individual small-scale farmer ☐

Commercial farmer ☐

Cooperative ☐ Name …….

Farmer group ☐ Name …….

3.How to you store the avocado ……

4.What means do you use to transport avocados from farmer to you area of operation

……

5.Do you incur any loses

Yes ☐ yes, how much do you lose……..

No ☐

6.What are the causes of the incurred loses

……

.7.What are you currently doing reduce the occurrence of the losses

……

……

8. what is social impact of the avocado production in your view

…… ……

……

9. What economic impact are you experience from avocado food loses

……

……

10. How do you get market information about the avocado

……

……

11. Do you get any support for your activities as a small scall farmer

Yes ☐ what type…… Name the giver ……

No ☐

12. What is your relationships with other chain actors (middlemen, exporters, processors)

Very poor ☐ Poor ☐ Good ☐ very good ☐

13.What is your gender

Female ☐ Male ☐

Annex 3 checklist for interviews with chain supporters

Check list for interviews with chain supporters

1 Introductions
2 Opening remarks.
3 kindly give a brief of the Sector description
4 what is your /company/ institutions roles in the value chain
5 How is information from your department shared to other avocado stake holders
6 what Partnerships and collaborations exist between you and other sectors
7 why are high food losses observed in the chain
7 what are the current challenges facing the sector
8 what measures have been put in place to overcoming
9 What are the current enabling /disenabling factors
10 what opportunities exist to reduce food losses
Closing remarks and appreciate the respondent

Annex 4 Checklist for interviewing chain actors

1. Introductions
2.Opening remarks.
3.kindly give a brief description of what you do in the avocado chain
4 How do you source the avocados
5 what king of producers do you deal with cooperative farmers,
farmer association, individual farmers or commercial farmers
6 what causes food losses
7 what amount are lost
8 what has been done by you to reduce this amounts
9 Any external support
10. Market information sharing channels
11.1Relationships with other stake holders
12.Suggestion to enhance food loss reduction along the chain
Closing remarks and thank the respondent

Annex 5.Table of results for independent t-test results

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Average	Equal variances assumed	.000	.989	-.197	14	.847	-.5625	2.8578	-6.6918	5.5668
	Equal variances not assumed			-.197	14.0	.847	-.5625	2.8578	-6.6918	5.5668

Annex 6. One way ANOVA comparing food loss quantities at different investigated stages

Multiple Comparisons

Dependent Variable: Average

LSD

(I) Stage of the value chain	(J) Stage of the value chain	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
preharvest	harvesting	-15.5000*	.7806	<.001	-17.300	-13.700
	postharvesting	-1.5000	.7806	.091	-3.300	.300
	storage	-.5000	.7806	.540	-2.300	1.300
	aggregation and transport	-1.5000	.7806	.091	-3.300	.300
	processing	2.0000*	.7806	.034	.200	3.800
	exporting	2.2500*	.7806	.020	.450	4.050
	distributing	.0000	.7806	1.000	-1.800	1.800

Annex 7. Descriptive statistics for Normal distribution of the used data

			Statistic	Std. Error
Qty harvested/tree/season	Mean		3835.00	291.098
	95% Confidence Interval for Mean	Lower Bound	3246.20	
		Upper Bound	4423.80	
	5% Trimmed Mean		3830.56	
	Median		4000.00	
	Variance		3389512.821	
	Std. Deviation		1841.063	

	Minimum	500	
	Maximum	8000	
	Range	7500	
	Interquartile Range	2500	
	Skewness	-.095	.374
	Kurtosis	-.453	.733

Annex 8. KS statistical test for data normality

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Qty harvested/tree/season	.128	40	.098	.965	40	.241

a. Lilliefors Significance Correction

Annex 9. Pictures of avocado varieties grown in Meru- County

Annex 10.Picture of key informant showing the researcher challenges in his farm

Annex 11. Transport facility by the company agent

Annex 12 . Focus group discussion with chain supporters

Annex. 13. Observed poor handling practices