SCALING MECHANISMS FOR AVOCADO LOSS REDUCTION IN MERU COUNTY, KENYA

ANGELINE ATIENO ONYANGO

Van Hall Larenstein University of Applied Sciences, Velp

The Netherlands

14/9/ 2022

SCALING MECHANISMS FOR AVOCADO LOSS REDUCTION IN MERU COUNTY, KENYA

A Research Thesis

Submitted to Van Hall Larenstein University of Applied Sciences in Partial

Fulfilment of the Requirements for the award of a Degree of Master Science in

Agricultural Production Chain Management, Horticulture Chains specialization

By

ANGELINE ATIENO ONYANGO

Supervised by: Albertien Kijne

Assessed by: Rik Eweg

This research was carried out as part of the SIA funded project "Food Waste Reduction and Food Quality Living Lab (FORQLAB)"
of the professorship Climate Smart Dairy Value Chains.

Van Hall Larenstein University of Applied Sciences, Velp

September 2022

ACKNOWLEDGEMENT

First, I would like to thank God who has made it possible for me to reach this far.

My sincere appreciation to the Government of the Royal Kingdom of the Netherlands and the Orange Knowledge (OKP) Program for offering me a scholarship for postgraduate studies in the Netherlands.

Am very grateful to Twiga Foods Limited for unreservedly granting me leave to study in the Netherlands. My gratitude to the teaching and non-teaching staff of Van Hall Larenstein University of Applied Sciences for all the guidance and support offered during my study period at VHL.

Special thanks to my specialization coordinator, mentor, and supervisor, Albertien Kijne for the mentorship and guidance throughout the research. It would have not been possible to carry out this research if not your guidance and support on what is expected of me.

Am very grateful to my course coordinator, Marco Verschuur, for giving me an opportunity to be involved in the ongoing project.

To my most supportive family, especially my mother, thanks for always motivating and guiding me.

DEDICATION

To the Almighty God, late Dad Francis Onyango, Mother Beatrice Awour, sisters, brother, and partner Dick Kiage. I hope that this achievement will complete one of the dreams that you had for me all those years

Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXES

ABBREVIATIONS

AFA	Agriculture and Food Authority
AGAK	Avocado Growers Association of Kenya
ASDSP	Agriculture Sector Development Support Program
ASK	Avocado Society of Kenya
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FORQLAB	Food Waste Reduction and Quality Living Lab
FSC	Food Supply Chain
(FFS)	Farmer Field Schools
HCD	Horticultural Crops Directorate
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KEPHIS	Kenya Plant Health Inspectorate Service
KNBS	Kenya National Beaurae of Statistics
Ltd	Limited
MLP	Multi-level perspective
(NARIG)	National Agriculture and Rural Inclusive
PCPB	Pest Control and Products Board
PPP	Public-Private Partnerships
PROMIS	Practice-oriented multi-level perspective on innovation and scaling
SDG	The United Nations Sustainable Development Goals
ToC	Theory of Change
3R	Robustness, Reliability and Resilience

ABSTRACT

Kenya's horticultural sector comprises of a diverse range of fruits, as the country's tropical and temperate climate zones facilitate the cultivation of a diverse range of horticultural crops. Avocado is one of the main horticultural products in Kenya that permits additional investments aimed at integrated sector development. Food loss refers to a decrease in the weight or quality of food that was initially produced for human consumption as the result of inefficiencies created along the food supply chain, for example poor logistics and infrastructure, insufficient technology, knowledge, skills, management capacity of supply chain participants, and market access. Approximately 15 % of avocados are lost in Kenya export supply system between the farm and the consumer, while for the domestic market, approximately 35 percent of avocado's harvested are lost before being consumed.

The reduction of postharvest losses is therefore increasingly recognized as crucial to the sustainability of food supply chains. The aim of this study is to identify, analyze and develop interventions targeting to promote the implementation and utilization of best practices as scaling mechanisms for reducing avocado losses among actors in Meru County.

The study is explored through a conceptual model, linking the concepts of value chain governance and scaling mechanisms to identify possible interventions for scaling avocado loss reduction in Meru County. Information was gathered through Focus Group Discussion and key informants from National Agricultural and Rural Inclusive Growth Project, Meru County Government, Meru university, Kenya Plant Health Inspectorate Service, Pest Control and Products Board, Kaguru Agricultural Training Institute, Kenya Agriculture and Livestock Research Organization, Ministry of Agriculture, Livestock and Fisheries, and Horticulture crop Directorate, Input suppliers, middlemen, broker, processors, exporters, oil extractors and retailers.

The findings revealed different roles and functions key actors, supporters, support services and knowledge institutes play in scaling avocado loss reduction. Current technical practices identified maturity indices, use of certified seedlings, limited application of pesticides to large scale farmers, manual harvesting, use crates for transportation, precooling, cold storage and established knowledge and innovation platforms. Current methodological practices that were identified include training and capacity building, extension services Private Public Partnerships, farmer field schools, and manual traceability system. It was also found that each of the practices contributes in different degrees to the reduction of postharvest losses.

It was found that technical practices to scale avocado loss reduction are influenced by several factors such as regulatory frameworks and government policies, inadequate knowledge, and lack of motivation. Therefore, an integrated approach of scaling avocado loss reduction needs to be considered.

CHAPTER 1: INTRODUCTION

1.1 Background

Kenya's horticultural sector comprises of a diverse range of fruits, as the country's tropical and temperate climate zones facilitate the cultivation of a diverse range of horticultural crops (Tyce, 2020). Avocado is one of the main horticultural products in Kenya that permits additional investments aimed at integrated sector development. Avocados originated in Latin America and have been cultivated in a varying range of environments including tropical and subtropical regions (Ayala and Ledesma, 2014).

According to FAO (2011) food loss refers to a decrease in the weight or quality of food that was initially produced for human consumption as the result of inefficiencies created along the food supply chain, for example poor logistics and infrastructure, insufficient technology, knowledge, skills, management capacity of supply chain participants, and market access. Food losses frequently occur in the early stage of food supply chains, from the farm until the processing stage (Gustavsson et al., 2011). Among the key priority areas in Kenya are reduced food losses, bundled at different levels of production and post-harvest supply chain stages (Verschoor et al., 2020).

Food losses impose enormous economic, environmental, and social costs in developing and developed countries (Meyer et al., 2017). This is also in accordance with Bustos and Moors (2018) who stated that postharvest losses along food supply chains have extensive environmental consequences and have an impact on the social and economic conditions of food supply chain participants, particularly those in developing countries. Insufficient harvesting technologies, poor handling, and improper storage has been attributed to 68 percent of total postharvest losses in Sub Saharan Africa (Kaminski and Christiaensen, 2014). The nature of fruits and vegetables in terms of perishability presents a serious challenge in efforts to mitigate losses in this sector (Wakholi et al., 2015).

Several measures are already in place to reduce avocado losses and improve quality. Endalew (2020), stated that efforts in East Africa to design and implement post-harvest technologies and handling methods to reduce post-harvest losses have proven to be ineffective and have no discernable effects, therefore research must be carried out intensively to scale up to reduce losses. Horticulture research has traditionally focused on increasing output while placing little emphasis on reducing post-harvest losses (Kitonja et al., 2011). The United Nations Sustainable Development Goal (SDG) 12.3 established a target, of reducing losses along the food value chain by half by 2030 (Wakholi et al., 2015).

Kenya has been facing challenges with weak governance structure in export and domestic markets (Matui et al., 2016). This in turn have an impact on the supply chain's sustainability, institutional governance, and the value chain's innovation support systems. A few of the avocado loss reduction practices have been developed in Kenya, including establishment of fruit processing companies, training of farmers on harvest handling techniques, post-harvest handling of avocadoes and establishment of reefers, as the cold chain infrastructure has not been developed (Snel et al., 2021).

Scaling is widely used in the context of “innovation and development initiatives”, as a set of strategies and approaches aimed at ensuring that the potential of isolated inventions, innovations, and developments benefits people and situations more broadly (Wigboldus, 2016). According to Wigboldus and Leeuwis (2013) identifying scaling mechanisms also known as interconnected causal is a key input into planning processes, therefore important component in change theories and related development.

The innovation system perspective recognizes the contributions made by all stakeholders involved in knowledge development, and dissemination, as it offers an analytical framework for studying technological change as a complicated task of actions and interactions among a diverse set of actors engaged in knowledge generation, exchange, and utilization (Leitgebet al., 2011).

1.2 Avocado sector in Kenya

In Kenya, avocado (*Persea americana Mill*.) is a significant perennial tropical crop that has shown to be a highly lucrative commercial crop for domestic as well as export market (Mokria et al., 2022). Cut flowers (KES 62.9 billion) continue to dominate the international export market, followed by vegetables (KES 20.9 billion) and fruit (KES 6.6 billion) (KNBS, 2016). Avocado production in Kenya is monopolized by small scale farmers (85%), who produce largely for exportation, with the rest sold in local markets (Wanjiku *et al.*, 2020). Since 2000, the acreage under avocado production has increased significantly, due to a high demand for avocado globally as consumers become aware of the dietary value, resulting to increased exports of avocados from Kenya (Johnny et al., 2019). Figure 1 depicts the production of avocado in Kenya since 2010 to 2022.

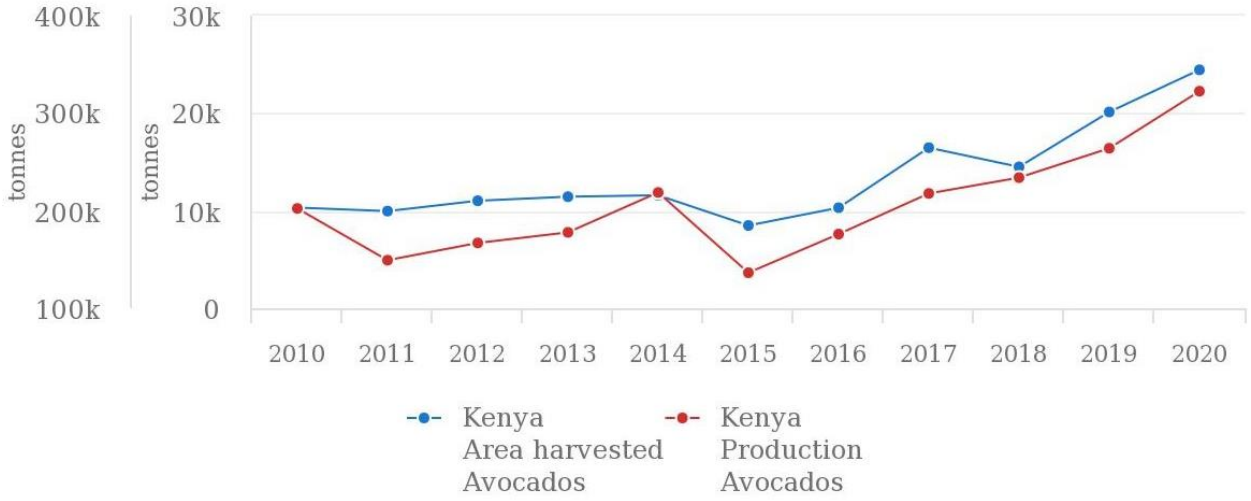

Figure 1: Avocado area harvested and production in Kenya (Source: FAOSTAT, 2020)

According to Toukem et al. (2020), Kenya grows over 40 avocado varieties, with Hass being the main export variety and Fuerte being preferred for processing. Snel et al. (2021), quantified that in the avocado export supply system, approximately 15 % are lost between the farm and the consumer, while for the domestic market, approximately 35 percent of avocado's harvested are lost before being consumed.

1.3 Avocado Losses in Meru County

Meru county is mainly known as the agricultural basket of the country. It is also famous for its large volumes of export of horticultural crops. Snel et al. (2021), stated that avocado has the potential to significantly increase rural household income in Meru County, as it is heavily investing in the sector's development. Several exporters are purchasing avocados in Meru. Located around the slopes of Mt. Kenya, it is served by a relatively good climate for avocado growing. Most of Kenya's Avocadoes thrive in eastern and central provinces, Meru being among the leading producers (Githiomi, 2019), potential loss reduction is higher. The crop grows between 200 and 1000 Meters above sea level, and the most common

in Meru are the Hass variety and the Fuerte. Other varieties, such as Pueblo perform exceedingly well above 2500 meters within the County.

Abogeta West Avocado Cooperative Society, a group of over 500 farmers with shared objective of sharing issues, have come together to promote avocado production and marketing. They link farmers to export market. According to Masinde (2022), there are numerous challenges that the farmers in general encounter across the avocado value chain in Meru County such as farmers not efficiently involved with the commodity, inappropriate harvesting time which results to un-uniform dry matter content and oil content, expensive equipment for determining maturity indices, and post-harvest losses.

1.4 The commissioner of the research

Food Waste Reduction and Quality Living Lab (FORQLAB) Project working in collaboration with the Abogeta West Avocado Cooperative on the development of avocado chain interventions in Kenya's food system is the commissioner.

1.5 Food Waste Reduction and Quality Living Lab (FORQLAB) Project

This applied research project focuses on the development of avocado chain (domestic and export chain) and dairy (domestic chain). In the central highlands of Kenya specifically Meru County, the project's goal is to contribute to the structural reduction of post-harvest losses of avocado, by implementing technical solutions and tools, as well as improving chain governance competencies. The regions chosen (central highlands) have a high potential for innovation adoption. The project involves different partners including universities (2 Kenyan and 4 Dutch), private sectors, organizations supporting the two chains and network partners.

1.6 Problem statement

An estimation of 35% of avocado products are lost before they reach the market or consumers because of inefficiencies in supply chains (Snel et al., 2021). The losses occur majorly from production to processing stage within the value chain which results into socio economic losses among actors in the chain and environmental degradation. This is attributed by insufficient harvesting technologies, poor handling, and improper storage. Literature identifies several best practices for reducing avocado losses, however there is insufficient information on the extent of implementation and utilization of these practices among actors in Meru County.

1.7 Justification

Based on the increasing demand for avocado both nationally and internationally, a study to assess the existing avocado loss reduction practices and develop intervention for scaling up avocado loss reduction across the value chain in Meru County was needed. The findings of this study were used as basis for developing recommendations for scaling avocado loss reduction for the stakeholders in Meru County.

1.8 Research objective

To identify, analyze and develop interventions targeting to promote the implementation and utilization of best practices as scaling mechanisms for reducing avocado losses among actors in Meru County.

1.9 Research question

1. What is the role of governance in promoting best practices for scaling avocado loss reduction in Meru County?
    a) What are the roles of chain actors and chain supporters in avocado loss reduction in Meru County?
    b) What is the performance of the chain in terms of stakeholders relations, policy harmonization and product flow towards scaling avocado loss reduction?
    c) What are the roles of formal and informal knowledge institutes in avocado loss reduction?
    d) What are the roles of support services towards reducing avocado loss reduction?
1. What are the scaling mechanisms that result to reduced avocado losses in Meru County?
    a) What are the current technical practices for scaling avocado loss reduction?
    b) What are the current methodological practices for scaling avocado loss reduction?
    c) What are enabling and disenabling environments in ensuring scaling up of avocado loss reduction?

CHAPTER 2: LITERATURE REVIEW

2.1: Avocado chain in Meru County

Figure 2 presents the avocado value chain map in Meru County.

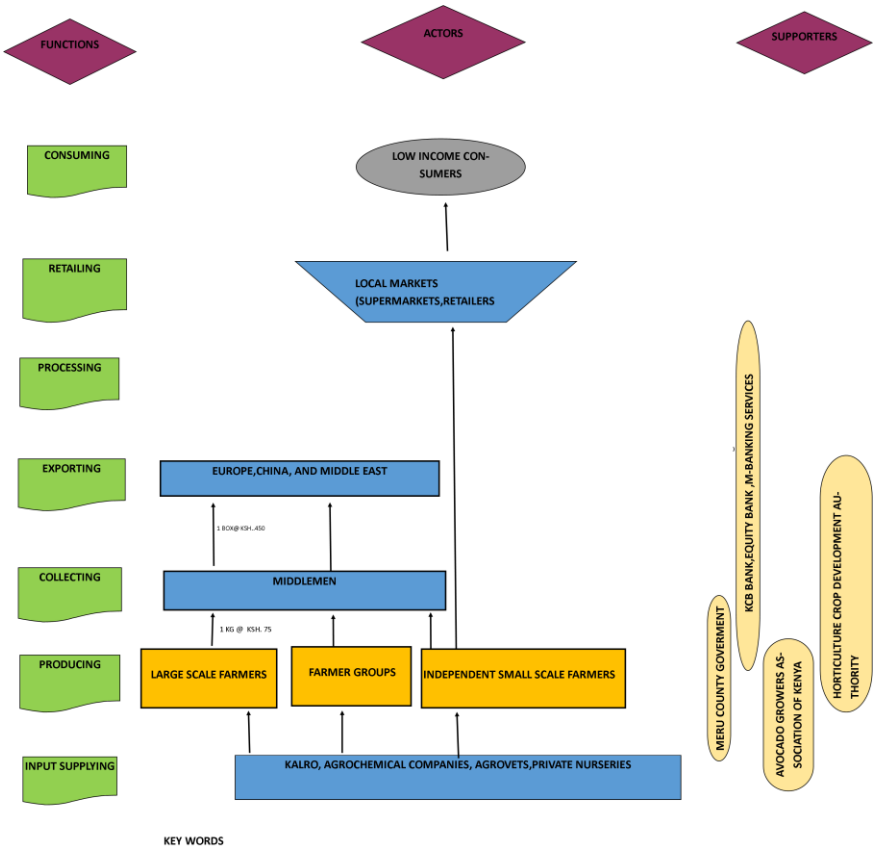

Figure 2: Avocado chain map in Meru County (Source: Woolf et al., 2009)

2.1.1 Chain Actors

According to Masinde (2022), production of avocado in Meru County is majorly carried out by small holder farmers who market their produce through middlemen who harvest grade and export while the rejects are sold on the local market. The large-scale farmers also supply avocado to the middlemen who export. Farmers groups such as Abogeta West Cooperative link farmers to the export market.

2.1.2 Chain supporters

Avocado Growers Association of Kenya (AGAK) coordinates producer organizations and links producers and exporters. Horticultural Crops Directorate (HCD) regulates avocado quality from production to export and Kenya Plant Health Inspectorate Service (KEPHIS) monitors and educates farmers and exporters on quality standards and safety issues (Ringo et al.,2022).

2.2 Scaling theory

The concept of scaling is widely used in the framework of innovation and development initiatives. It refers to strategies and approaches, aimed at ensuring that the potential of secluded innovations, and developments are beneficial to people and situations more broadly (Wigboldus, 2016). While scaling processes originate from within system and boundaries such as value chain, they tend to affect and be

affected by factors that lie beyond the boundaries of the systems, domains, and levels, therefore involve stakeholders at different levels in the systems (Wigboldus et al., 2016). Figure 3 presents the scaling process.

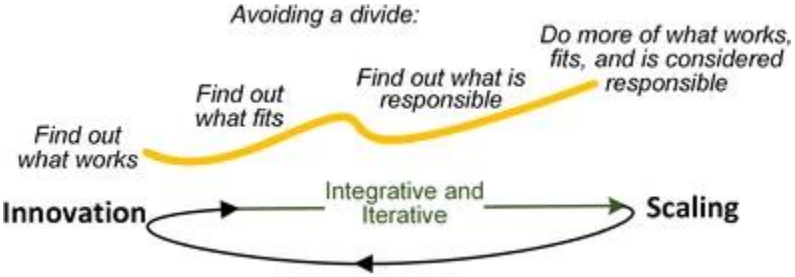

Figure 3: Scaling process (Source: Wigboldus et al., 2016)

Scaling technologies and practices frequently involves changes in elements such as production systems, and markets systems (Hassink et al., 2013). According to Wigboldus *et al.* (2016), scaling processes involve a diverse set of stakeholders from both niche areas and regulatory frameworks. Traditional linear approaches to innovation have given way to participatory and collaborative interactions within stakeholders (Granstrand and Holgersson, 2020). Scaling processes are conceptualized in a variety of ways. Steenbergen et al. (2022), theorize that successful scaling necessitates involvement with all aspects of a governing regime and bringing diverse range of actors together.

Neufeldt et al. (2015) mentioned that there will always be an overlap among horizontal, vertical, and diagonal scaling processes, along with direct and indirect approaches. Direct approaches are whereby an organization is unswervingly accountable for effecting change. Indirect approaches are whereby an organization attempts to influence others to transformation and implement new practices or policies (Neufeldt et al., 2015).

Push, pull, plant, and probe are overall approaches to engaging with scaling situational factors (Wigboldus and Leeuwis 2013). According to Wigboldus and Leeuwis (2013), push, pull, plant and probe approaches connects to different situations in which scaling initiatives occur. 'Push' approach is suitable in situations which are uncomplicated and with little uncertainty and disagreements (Wigboldus and Leeuwis 2013). 'Pull' approach is a better fit in technically complicated situation for example, if we have an aspired future in mind and seek to scale that which we think will help make that future reality. Searchinger et al. (2013) stated that the push approach corresponds to the more common understanding of something we would be interested in scaling while pull approach refers to common practice, which is frequently overlooked as an indirect scaling strategy. This is relevant to agenda setting and policymaking, for example, sustainable food systems context. 'Plant' approach is suitable in a socially complicated situation such as we have something we would like to see go to scale, but such scaling can only happen if we connect other factors and work with other (development) actors (Wigboldus and Leeuwis 2013). 'Probe' approach can be used in situations where there is a lot of uncertainty and disagreements for example if we have an aspired future in mind but are unsure about what scaling processes would be involved in moving towards that future (Wigboldus and Leeuwis 2013).

Theory of scaling adapted from Theory of Change is effective when it incorporates the perspective of different stakeholders. Scaling up is frequently used in theories of change (ToC), where successful thoughts or practices should be 'brought to scale' (Steenbergen et al., 2022). The Practice-oriented multi-

level perspective on innovation and scaling (PROMIS) framework can be used to organize an overview of actor perspectives considering a proposed scaling initiative, for example what different stakeholders view as the most important aspects to be considered in the initiative (Wigboldus, 2016). PROMIS framework combines two approaches in terms of analysis. According to Geels (2019), multi-level perspective (MLP) provides a lens for understanding how innovations 'travel' across multi-scalar structures, to eventually be absorbed into systems and practice, moving from small experimental innovation to institutionalization to broad societal absorption. 'Responsible innovation and scaling' necessitate anticipating negative scaling effects because innovations that works in a particular place or situation may not be successful in another place or situation and vice versa (Wigboldus and Leeuwis 2013).

2.3 Scaling processes

Scaling out refers to replication, expansion, extension, adoption, dissemination, transfer of technology and mainstreaming (Wigboldus and Leeuwis, 2013). Scaling up is derived from a research and development model that envisions conducting research to identify potential improvements to agricultural practice, testing and refining these interventions in pilot locations, and then widely disseminating the refined interventions (Coe et al., 2014). Scaling up refers to a change, institutionalization, integration, growth and or development (Wigboldus and Leeuwis, 2013). According to Linn (2012), successful scaling up requires both appropriate practices, and technologies, or models within favourable enabling environments, such as supportive institutional arrangements, policies, and finance at local to national levels.

Another type of scaling which is commonly used in literature differentiates scaling types as vertical scaling up, horizontal scaling up and diagonal scaling up (Linn, 2012; Makate, 2019). Scaling up can occur horizontally by replicating proven practices, technologies, or models in new geographical areas or target groups, or vertically by enabling institutional and policy change and diagonally by adding project components, changing project configuration, or changing strategy in response to emergent reality (Linn, 2012; World Bank, 2013). Scaling up is not simply the next step after determining what works. The design of research and innovation projects must consider future scaling-up from the start (Ghiron et al., 2014), in terms of objectives, and improving anticipation of the implications of choices in innovation agendas.

Horizontal scaling up encompasses duplicating verified practices, technologies, or models in new geographic areas or target groups (Linn, 2012) and is suitable in homogenous and high population density areas. Vertical scaling up entails accelerating institutional and policy change by demonstrating the efficacy and efficiency of practices, technologies, and models, thereby removing barriers to wider adoption by a larger number of practitioners (Aggarwal *et al.*, 2018). Vertical scaling up involves creating institutional conditions that allow the scaling of innovations to happen (Wigboldus, 2016). Vertical scaling up is usually complex as it entails more uncertainty in relation to outcomes of scaling process than horizontal (Gebreyes et al., 2021). Diagonal scaling up entails adding project components, changing project configuration, or changing approach in response to emergent reality (Neufeldt *et al.*, 2015). Figure 4 shows the difference and connection between scaling up, scaling out horizontal and vertical scaling.

	Scaling out	Scaling up
Horizontal scaling	Multiplication at same scale level (e.g. spreading processes, such as wider adoption of technology or of an institutional arrangement within e.g. same district)	Innovation/development (institutional/technological/ etc.) at same scale level (e.g. from local cooling system to local dairy business hub, or from local regulation to local regulatory framework)
Vertical scaling	Multiplication towards different scale levels (e.g. extension processes, or policy adoption of local practice towards country-wide application)	Innovation/development (institutional/technological/ etc.) towards different scale levels (e.g. from local dairy business hub to national fresh-food system, or from local regulatory framework to national policy)

Figure 4: Connection between scaling up, scaling out, horizontal and vertical scaling. (Source; Wigboldus, 2016)

2.4 Overview of value chain governance

Dietz (2012) states that governance is the relationships between the various chain actors who operate different activities needed to bring product or service from inception to end use. The key parameters that are enforced are: product design and specifications, definition of the production processes, for example the technology needed, quality systems, product, labour and environmental rules, production scheduling and logistics (Dietz, 2012). The collaborative development of robust, reliable, and resilient subsystems can determine the sectors' maturation and make them more appealing for trade and investment (Kessler *et al.*, 2020).

According to Dengerink and Rijn (2018), the avocado value chain in Kenya is characterized by weak institutional capacity of small-scale producers and coordination of fruit export. This is because of insufficient capacity of farmer groups and small-scale producers to improve accountability and quality of the avocados in the value chain. Furthermore, there is lack of market information and transparency in domestic avocado market (Snel et al., 2021). A few avocado farmers are formally organized into producer organizations and have contractual arrangements with marketing agents and buyers (Rampa & Dekeyser, 2020).

2.5 3R Framework of Governance

According to Ghiron et al. (2014), scaling agricultural innovations necessitates a careful balance of technical requirements and the social dynamics that surround scaling targets, actors involved, and their social relationships. Several challenges face the horticulture industry in Kenya, which in turn have an impact on the supply chain's sustainability, institutional governance, and innovation support systems across the value chain. Therefore examining 3R framework (robustness of the chain, resilience of the innovation support systems and reliability of institutional governance) enables a better understanding of the horticulture sector's robustness, reliability, and resilience (3R) (Matui *et al.*, 2016).

Robustness refers to the efficient and trustworthy interactions among supply chain actors and supporters (Matui et al., 2016). Efficient interactions lowers transaction costs as well as the risks associated with improving product quality and safety, as well as bolstering sustainability and adaptability (Bebe *et al.*, 2015). Robustness of the chain entails productivity, flow, and quality of the product within the chain.

Reliability of institutional governance refers to a policy framework that encourages investment and collaboration to improve trade opportunities (Rijn, 2016). Reliability of institutional governance involves

agreements, laws, and regulations. Reliability also involves relations between enablers such as cooperatives and policy setters.

Resilience of the innovation support system is an important aspect in the scaling of the innovation systems. Resilience of innovation support systems is the ability to address challenges and capitalize on growing opportunities and is dependent on actors constantly exchanging and applying knowledge, mobilizing resources, and coordinating co- innovation networks (Bebe et al., 2015). Matui et al. (2016), describe resilience as the dynamic adaptive capacities that allow agents for example research, extension, projects, and systems to respond appropriately to changing circumstances.

Although the private sector is not well developed in Kenya because the economy is still informal, commercial sectors such as avocado have witnessed and benefited from the rise of the private sector (Matui et al., 2016). Kessler et al., (2020) stated that producer organizations in Kenya, such as cooperatives, continue to be vulnerable due to limited entrepreneurial and internal governance capabilities, as well as insufficient compelling value proposition for their members.

2.6 Best practices in reducing avocado losses

Sector learning, research, and development, as well as innovation, are systemic issues associated with resilient innovation support systems (Kessler et al., 2020). Numerous efforts have been made by various stakeholders to implement strategies to minimize these losses. Best practices in reducing avocado losses cuts across technical and methodological practices.

2.6.1 Technical practices

Avocado is produced majorly for commercial purposes in most parts of the world. Avocado product is highly perishable and requires proper handling. Losses occur at different stages from production, harvesting, transportation handling, storage, processing, and distribution to consumption. Pre and postharvest losses in food supply chains result to environmental consequences and have an impact on the social-economic conditions of food supply chain participants, particularly those in developing countries (Arias Bustos and Moors, 2018). Postharvest loss is the reduction in quantity and quality of food production from harvest to consumption (Bereda, 2016).

Production

There are several pre-harvest factors that, if not well managed, can interfere with the quality of the fruit thus reduce the shelf life (Tyagi *et al.*, 2017). Pre harvest losses of avocados can be caused by environmental conditions and poor agricultural practices. These losses can be reduced by using precision farming techniques and tools. Precision farming is whereby inputs such as fertilizer, herbicides and pesticides are given in correct amounts, where needed and when needed thus enable planning of harvesting and logistics (Balogh et al., 2021).

Harvesting

Avocado fruit is one of the few fruits that does not ripen while attached to a tree (Magwaza and Tesfay 2015). They are therefore picked when mature but unripe to withstand postharvest handling systems such as transportation (Kassim et al., 2013). Villa-Rodriguez et al., (2011) stated that the complete ripening process of avocadoes is five to seven days at 25°C.

Erkan and Dogan (2019) stated that avocado should be harvested at precisely right stage of development, without mechanical damage, which can degrade the fruit's superficial appearance and serve as an entry point for postharvest pathogens that cause decay during storage and transportation (Singh and Sharma, 2018). To avoid damage to the fruit, avocado is typically placed in either a soft picking bag tied to a harvesting pole or into a plastic crate and relocated to the shade to reduce weight loss, due to rapid moisture loss when exposed to the sun (Bill *et al.*, 2014). Sunlight tends to raise the temperature of the pulp, accelerating ripening and shortening the shelf life.

According to Kassim et al. (2013), clippers can be used to remove fruit from trees, however about 1 cm of the pedicel should be left attached to the fruit. Harvesting methods have been shown to affect the postharvest fruit quality of 'Fuerte,' which requires manual clipping of pedicels (Hernández et al., 2016). 'Hass' should be snap-picked, to avoid undesirable effect on the quality of the fruit (Bereda, 2016).

Avocado harvest maturity is often determined by indices such as mesocarp oil, dry matter, or moisture content, which are all quantified using representative samples (Magwaza and Tesfay, 2015). Dry matter content of avocados can be determined by drying a representative portion of the product in an oven at temperatures around 70°C or by drying in a microwave oven (Magwaza and Tesfay, 2015). Avocado fruit's nutritional value is distinguished by its high oil content, which is primarily composed of unsaturated fatty acids (Donetti and Terry 2014). Minimum dry matter content ranges from 17 to 25 % depending on cultivar (19.0 % for 'Fuerte' and 20.8 % for 'Hass') and county (Kassim et al., 2013).

Additionally, some harvesting techniques damage immature avocados; hence they are not marketable. Improved harvesting methods such as ladders produce maximum yield by reducing damages. Based on Bustos and Moors (2018), collaboration between stakeholders reduce harvest losses by training the avocado handlers on the best way to harvest, store, and package avocado products.

There are several advantages to manual harvesting over mechanical harvesting. According to Ramírez et al. (2019), manual harvesting causes much less mechanical damage to the fruits and is selective, which is significant because the maturity stage of most fruits in the same location can vary greatly, thus need to be picked at intervals.

Precooling

Avocadoes must be cooled as soon as possible after harvesting to delay ripening (Arpaia et al., 2015). Pre-cooling to about 16 °C to remove the field heat is very important, especially when the field temperatures are high (>25 °C). Commercially, hydro cooling is the most common method used (Bill et al., 2014).

Packaging

Postharvest loss reduction requires improved packaging such as crates, coatings, and retail packaging lines because avocadoes are highly fragile. The packages should be well ventilated and hold a weight of maximum 20 kg without piling on top of each other to avoid damages (Bereda, 2016). According to Snel *et al.* (2021), packaging can significantly reduce avocado losses by 30-40 %, even though it tends to work perfectly when combined with other interventions such cold storage and aggregation.

Transportation

Measures can be adopted to reduce losses during the transportation stage, such as use of wooden or plastic racks in the truck, to allow air circulation and minimize heat buildup or using environment-

controlled trucks (Kimaro and Msogoya, 2012; Kereth et al., 2013). Temperature regulation of the transport system is also important in reducing losses especially in highly perishable fruits such as avocados.

Cooling and storage

Temperature management is a method used for preserving the quality of avocados, lowering qualitative and quantitative losses, and extending their postharvest life (Bill et al., 2014). Avocadoes have benefited from storage conditions containing high concentrations of carbon dioxide and low concentrations of oxygen, combined with low temperatures. In Kenya, technologies that would assist in reducing post-harvest losses and improve cooling and storage such as charcoal cooling are not well developed as the adoption is still not widespread (Matui et al., 2016).

Post-harvest value addition and processing facilities

Fruits processing is becoming more popular, due to the need to extend shelf life thus reduce losses. Processing reduces avocado losses by extending its shelf life and as they can be processed into a variety of products such as juice, oil, dried products, and guacamole (Snel et al., 2021). Oil extraction and drying are the most often used methods. Sweetunda, a product of the Burton & Bamber agro-processing company located in Thika, Kenya , is already preserving fruits and other crops, hence contributes to the reduction of post-harvest losses (Matui *et al.*, 2016).

2.6.2 Methodological practices

To reduce food loss at the production, distribution, processing, and wholesale levels, new thinking, partnerships, and actions are required (Delgado et al., 2017). Governments, private businesses, research institutions, policy makers, and chain actors need more education, increased awareness, and behavioral change. Individual and collective capacity in aspects such as learning, decision-making, and strategic planning can contribute to the creation of the necessary enabling conditions, making this an essential area for investment in guiding responsible scaling in agricultural development (Wigboldus and Leeuwis 2013). Reynolds et al. (2019), mentioned that Public-Private partnerships and Citizen behaviour change campaigns approaches seem to be effective and can work at scale.

Public-Private partnerships

Public-Private partnerships (PPPs) are programs in which public and private sector organizations make commitments to improve their environmental performance, without legislation or additional regulations (Boulding and Devine 2019). Public-Private partnerships have been proven to be successful in tackling food losses in European Union countries by covering a wide variety of sectors and stakeholders across the food chain (Matzembacher et al., 2021). Public-Private partnerships can provide more efficient, adaptable, and effective regulatory structures than traditional regulatory structures (Abbott and Snidal 2021). This is because it supports the idea that collective action can be more cost-effective and have a greater impact than when organizations address issues individually (Abbott and Snidal 2021).

WRAP (2019b) mentioned that PPPs facilitate collaboration between stakeholders and supply chains and highlight the best practice approaches necessary to deliver change. The approaches include making sure new PPPs adhere to core principles and well-defined fundamentals, obtaining government assistance and identifying the most appropriate lead organization (WRAP, 2019b). Additionally, it also involves ensuring that PPPs have enough resources to assist signatories in meeting targets and developing new ones,

continually revising the dynamics of PPPs, and comprehending the mechanisms required to ensure their success and developing additional methods for tracking and evaluating progress (WRAP, 2019b).

Citizen behaviours change campaigns

Vlaev *et al.*, (2019) suggested that policymakers should use additional interventions based on regulation, and economic instruments to effectively support citizen behavior-change campaigns. These may be best harmonized by developing a national food strategy to provide an integrated approach to food loss that links to, economic policies, and wider resource efficiency and loss policies. This must be monitored and evaluated to gain insights into their effectiveness and allow for adjustments to further improve food loss (Vlaev et al., 2019).

Learning and knowledge platforms

According to Kessler et al. (2020), sectors with well-developed innovation systems exhibit resilience and adaptability to new challenges and opportunities and the potential is found on systemic issues such as the presence and effectiveness of learning and knowledge platforms that facilitate and support knowledge exchange and innovation, as well as the existing research, development, and education systems.

Innovation platforms foster learning and create change (Misiko et al., 2013) as they bring actors together to share knowledge and find solutions to common problems in an unbiassed and dynamic space (Cadilhon, 2013). Innovation platforms are flexible and diverse as response can be issued out quickly to emerging problems and opportunities (Homann-Kee Tui et al., 2013). Innovation platforms enable solving of problems that require collaboration of several actors and develop better solutions than individual actors (Homann-Kee Tui et al. 2013; Posthumus and Wongtschowski 2014) as they identify bottlenecks that stifle innovation.

One of the best ways to reduce food losses along food supply chains (FSC) is to exchange information (Kapia et al., 2013), However, the most structural inefficiencies along the FSC are the reserve of FSC participants to exchange information due to fear of losing competitive advantages, being exposed to opportunism, and losing bargaining power.

Extension approaches

Various extension approaches such as farmer to farmer and farmer field school, rural resource centers and relay organizations and innovation platforms can assist in spreading innovations (Neufeldt et al., 2015). Volunteer farmer trainers train their peers, mobilizing people to disseminate information and promote agricultural technology adoption (ICRAF, 2015) and has been proven to be successful in reaching more women farmers due to the potential to select female farmers for extension roles (Simpson et al., 2015). According to Lukuyu et al. (2012), farmer trainers recruited from existing farmer groups and trained in technology, communication, and capacity-building skills are most effective in dissemination of simple technologies. Experience in western Kenya has shown that local institutions such as local government and producer organizations must own farmer-to-farmer extension programs for them to be sustained (Franzel et al., 2015).

Technology demonstrations are more important to development actors than knowledge system development because knowledge systems are not immediately visible and take time to establish and deliver results (Matui *et al.*, 2016). However, there is a high demand for training (knowledge

dissemination) in the absence of a clear pathway for knowledge adoption (Matui *et al.*, 2016). Projects are frequently designed to train a specific number of farmers rather than to train a specific number of farmers to adopt specific practices (Matui *et al.*, 2016). According to Matui et al. (2016), based on Tradecare's experience it was revealed that there is a significant gap between knowledge dissemination and adoption.

Farmer field schools, which enable field-level learning and problem solving among farmers, are a popular approach for enabling farmer-to-farmer extension (Neufeldt et al., 2015). To increase practice adoption, farmers must be involved in the development of new technologies from conception to distribution, as well as facilitate farmer groups and build their technical capacity (Bertin et al., 2014).

2.7 Conceptual framework

The conceptual framework (Figure 5) presents a summary of the key concepts, dimensions, and research indicators

that were used in the research. The first is the value chain governance concept which was selected to identify the functions and roles of stakeholders, policy harmonization, product flow, stakeholder relations and enabling and disenabling environments towards reducing avocado losses. Secondly, current technical and methodological practices in scaling were identified with an aim of suggesting improvements in the gaps.

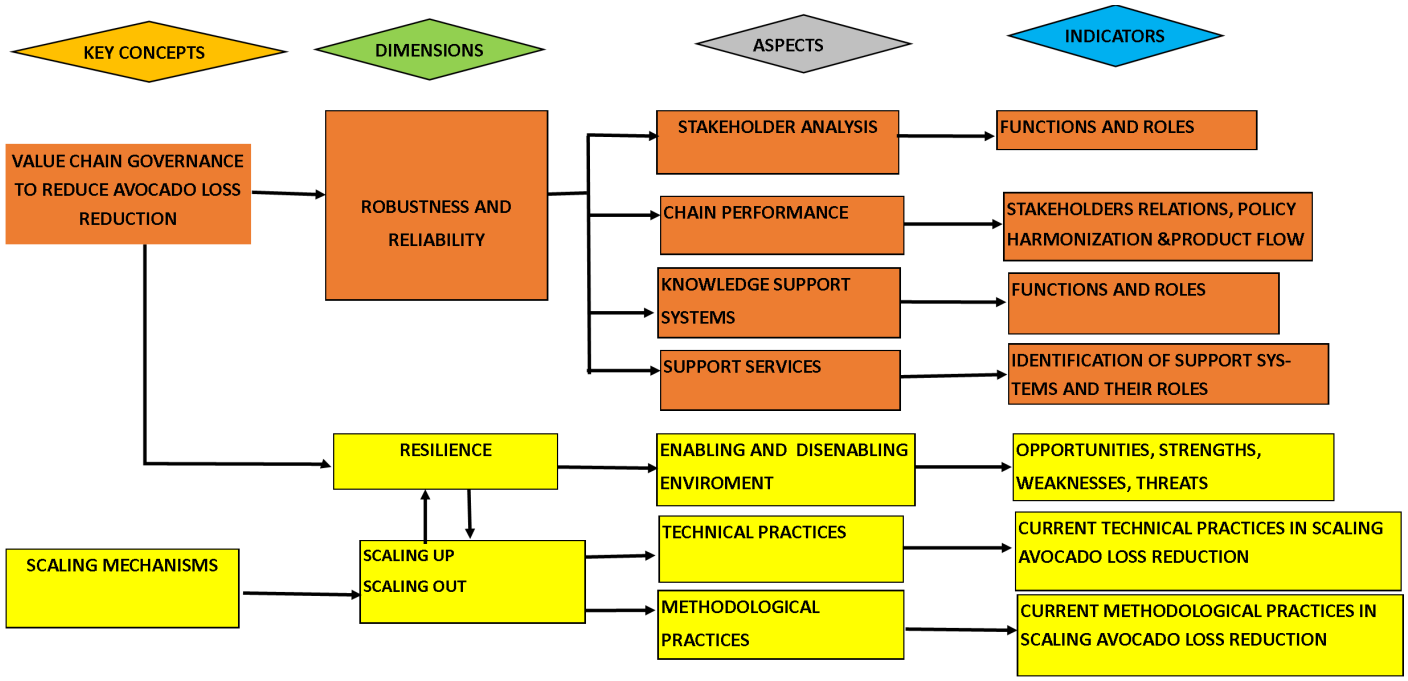

Figure 5: Conceptual framework. (Source: Author, 2022)

CHAPTER 3: METHODOLOGY

3.1: Description of study area

Research was conducted in Meru County of Kenya. Meru county is one of the biggest producers and leading exporter of avocado in Eastern Kenya. Meru County lies on the Northeastern part of Mt. Kenya. Meru County borders Isiolo County to the North, Laikipia to the West and Tharakanithi, Nyeri, Kirinyaga and Embu Counties to the South. It occupies an area of 6933 km square.

The rainfall distribution ranges from 300mm to 2500 mm per annum with average temperatures ranging from 8^0 C to 32^0 C during the cold and hot season respectively (Gakuubi and Wanzala 2012). Meru County has high levels of agricultural productivity, with predominantly rain-fed agriculture accounting for roughly 80% of household income (MoALF, 2016). Meru County's main high-value crops are watermelons, French beans, and fruit trees such as mangoes, avocadoes and Khat (Miraa) (Imaita, 2013). Figure 6 depicts the map of Meru County.

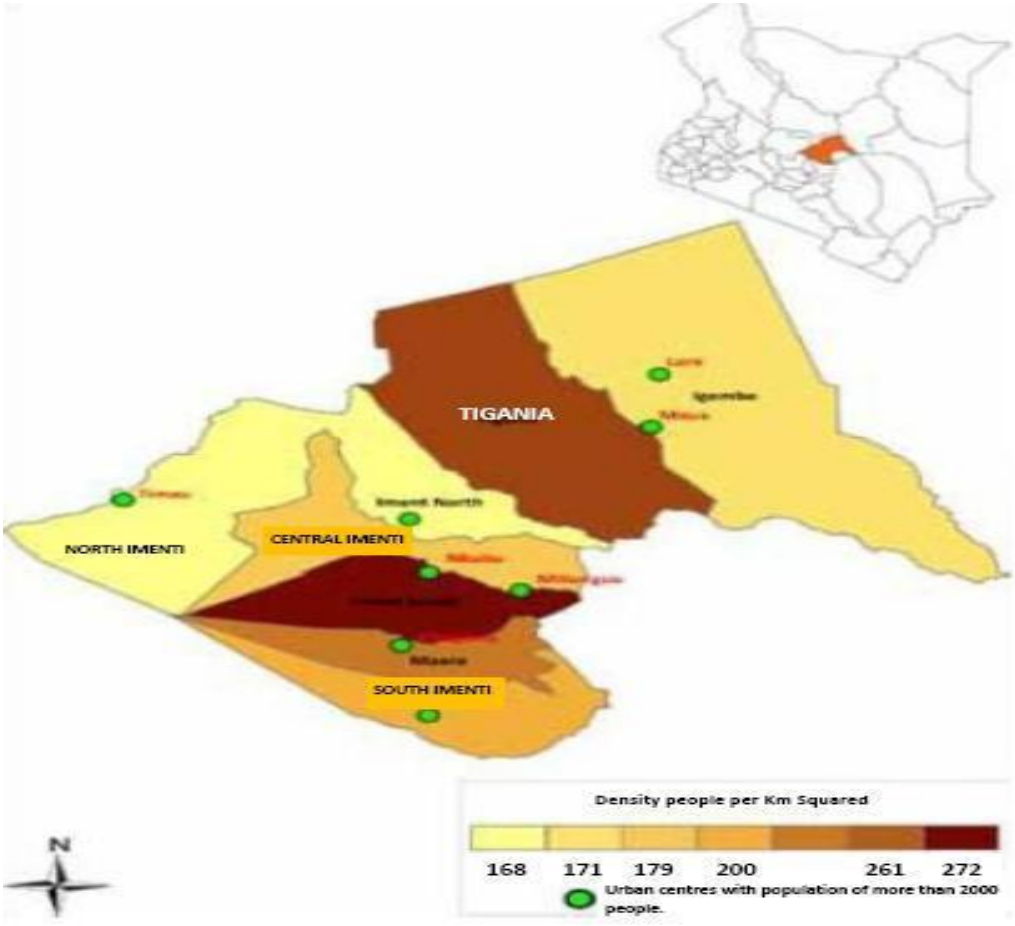

Figure 6: Map of Meru County (Source: Google Maps, 2022)

3.2: Research design

The research aimed to identify scaling mechanisms for avocado loss reduction in Meru County. Qualitative research approach was used to gain deeper understanding of the avocado value chain, roles of chain supporters and chain actors in reducing avocado losses, information flow among actors and supporters in

ensuring reduction of avocado losses best practices carried out in Meru County to reduce losses and technical and methodological practices for scaling avocado loss reduction.

3.3 Data collection

Interviews

To complement the information obtained from the literature, in-depth interviews were conducted among different key stakeholders within and outside the chain. Interviews were used to acquire in depth information from key informants. Key informants from National Agricultural and Rural Inclusive Growth Project (1), Meru County Government (2), Meru university (1), Kenya Plant Health Inspectorate Service (1), Pest Control and Products Board (1), Kaguru Agricultural Training Institute (1), Kenya Agriculture and Livestock Research Organization (2), Ministry of Agriculture, Livestock and Fisheries (1) and Horticulture crop Directorate (1) were interviewed were interviewed to collect data on the different aspects of the research topic. The funded program, NARIG project was chosen due to their role in the development of the horticulture chain, avocado being one of the target crops. Chain actor Such as Input suppliers (3), middlemen (2), brokers (2), processors (2), exporters (2), oil extractors (1) and retailers (5) were interviewed. Five individual farmers who are not members in any producer organizations were also interviewed to acquire their own points of view.

A snowball technique was used whereby the chairperson from Abogeta West Avocado Cooperative was used as a starting point for orientation and as key informant and then further referrals were carried out through phone calls and emails. Through referrals, chairpersons of Abuduguchi Organic Avocado Growers and Meru Avocado Champions Group were also interviewed for comparisons. Checklist in annex 1 was used as general guidance during the interviews in relation to the sub-questions.

Focus group discussion

First and foremost, an orientation meeting was organized to meet the chairperson of Abogeta West Avocado Cooperative as a starting point in data collection. Thereafter, a convenience sampling method was used to identify focus group discussion members. With the assistance of the Abogeta West Avocado Cooperative chairperson, contacts were made through phone calls and selection was done based availability.

Two Focus group discussion were conducted at the farmers level, because of the anticipation of large population of farmers and the need to gain collective understanding. The first focus group discussion (FGD) was composed of 6 respondents of Abogeta West Avocado Cooperative management team. The FGD comprised of 1 female and 5 males. The FGD was for supposed to comprise of 2 females who are in the management team, but it was only possible to have one female member. The second focus group discussion comprised of 8 members with 1 female and 7 males. The FGDs was planned for 10 members each with a gender balance, however, due to unavailability, it was possible to have 1 female. Additionally, during the orientation meeting, it was mentioned that majority of the avocado farmers are males because tree crops in Meru County is perceived to be a ‘men’ crop, therefore getting female participants was difficult. Majority of the respondents were above 65 years of age. Based on Abogeta West Avocado Cooperative key informants, majority of avocado farmers are between the age of 57-75 years. The pictures below illustrate FGD in Chure social hall, South Imenti Constituency.

Figure 7: FGD in Chure social hall (Source: Author,2022)

3.4 Data processing and analysis

Data collected through focus group discussion and interviews were transcribed and categorized into themes. After categorization, analysis was done to consolidate meaning and explanation. The information was presented in tables and illustrative quotes to enhance credibility and reliability of the results. Stakeholder matrix and value chain map was also used during the processing and analysis for identification of the roles and functions of farmers. The data was presented in form of tables, Stakeholder matrix, value chain map, SWOT Analysis.

Table 1 shows the method of data collection, number of respondents at each level in the chain, method of processing and analysis, and presentation methods that was used.

Sub-questions	Presentation methods
1a. What are the roles of chain actors and chain supporters in avocado loss reduction in Meru County?	Stakeholder matrix Value chain map Narrative form Fieldwork pictures Tables
1b. What is the performance of the chain in terms of stakeholders relations, policy harmonization and product flow towards scaling avocado loss reduction?	Narrative form
1c. What are the roles of formal and informal knowledge institutes in avocado loss reduction?	Narrative form Stakeholder matrix
2a. What are the current technical practices for scaling avocado loss reduction?	Narrative form
2b. What are the current methodological practices for scaling avocado loss reduction?	Narrative form
2c. What are the enabling and disenabling environments in ensuring scaling up of avocado loss reduction?	SWOT Analysis Narrative form

Table 1: Data collection methods, processing and analysis methods and presentation methods (source: Author, 2022)

3.5 Limitations of the research

i. The research focused much more on the resilience aspects in the 3R framework of governance and on specific aspects in the reliability and robustness frameworks which are directly linked to the topic.
ii. Limited number of individual farmer participants. Some interviews organized with other individual farmers did not happen as was planned.

3.6 Ethical issues

Before conducting the interviews and FGD, the researcher ensured that the purpose of the research was well explained to the respondents. The researcher also sought the respondents consent and willingness to participate in the interview. The respondents' confidentiality and anonymity were assured to by the researcher. Permission for recording and taking of pictures was also requested beforehand.

CHAPTER 4: FINDINGS

This chapter presents the findings from the field research. The results are presented using tables, chain map, SWOT Analysis, narrative form, figures, and stakeholder matrix.

Current trends of avocado production in Meru County

According to Meru County Government, avocado production in Meru County is estimated to be 17500 metric tonnes per year. The current varieties that are grown are the Hass and Fuerte varieties majorly for export while the local variety Jumbo, is grown for local market. Meru County Government representative also mentioned that 30 % of avocadoes are lost at the production level. According to interviews with different key informants and focus group discussion participants, various causes of avocado losses were identified. This includes pest and diseases such as fruit flies, false codling moth, anthracnose and rust which affect the quality and productivity, high cost of inputs, immature harvesting of avocadoes by farmers, poor harvest techniques, post-harvest handling of avocadoes, late picking of avocadoes due to difficulty in finding market, immature harvesting of avocadoes, poor collaboration among stakeholders, and poor storage systems.

4.1 Roles of chain actors and chain supporters in avocado loss reduction in Meru County

Avocado chain in Meru County consists of different stakeholders who play different roles in reducing avocado losses.

4.1.1 Chain actors and their roles in reducing avocado losses

The study reveals different chain actors who are currently involved in avocado loss reduction in Meru County as shown in the stakeholder matrix in table 2. The following are key actors involved in avocado chain in Meru County:

i. Input supplying

Through farmers Focus Group Discussion, it was revealed that less than 30% of farmers acquire inputs such as fertilizer and pesticides from input suppliers. The farmers mentioned that they rarely use pesticides and fertilizers in avocado production. Acquisition of avocado seedlings is usually from the uncertified, local nursery growers at KES. 150-300. Through the discussion it was also discovered that the farmers who purchase uncertified avocado seedlings usually end up cutting down the tree because of undesired varieties. The respondents mentioned that uncertified avocado seedlings are highly susceptible to pest and diseases. The participants also revealed that government institutions such as KALRO and Jomo Kenyatta University of Agriculture and Technology (JKUAT) sell certified avocado seedling at KES. 120, while private licensed nursery growers sell between KES.150-300.

Regarding their roles as input suppliers in reducing avocado losses, input suppliers mentioned that they advise farmers on the safe use, handling and pre harvest interval practices, rates of pesticides and fertilizer application. This is done with the coordination of Pest Control and Products Board.

ii. Producing

During the FGD, it was revealed that there are different groups of avocado farmers such as those registered in cooperatives and groups, individual farmers, contracted farmers, company owned farmers and local varieties farmers. 90% of the avocado farmers are small-scale farmers who possess an average of 1-50 trees and manage their farms with family labour or casual workers. Interviews with exporters

revealed that producers like Keitt Exporters perform both functions of producing and exporting. Interviews with farmers, NARIG project representative, Meru County HCD representative and middlemen revealed the existence of avocado farmer organizations which include Meru Avocado Champions, Abogeta West Avocado Cooperative, Abuduguchi Organic Avocado growers, and Mugamboni Fruits and Nuts Supplies. Mugamboni Fruits and Nuts Supplies consist of about 70 members, Abogeta West Avocado Cooperative, 500 members, Meru Avocado Champions, 70 members and Abuduguchi Organic Avocado growers, 80 members.

Majorly farmers in the producer organizations grow hybrid varieties such as Hass and Fuerte for export market. Individual farmers growing hybrid varieties sell their avocadoes to the middlemen through brokers. Individual farmers mentioned that they are currently selling to middlemen at KES. 11 per piece.

When asked about the prices for avocado, Abogeta west Avocado Cooperative key informant stated that: "*For this year, the cooperative concluded an annual contract with an exporter, Biofarms Ltd. The negotiated price was initially set at KES. 19 per avocado. However, as the markets are momentarily very bad, the contract had to be renegotiated. Currently, the buying price is unfortunately much lower: brokers buy the Fuerte avocados for 10 Kenyan shilling per piece and Hass avocados for KES. 15 per piece. The rejects for example pest and disease infested avocadoes, mechanically damaged, oversize, and overripe avocadoes are sold to oil extraction companies at KES. 20 per kilogram*."

To reduce avocado losses, the farmers mentioned that they use traditional methods such as wood for pest and disease control, burying method of pest and disease infested avocadoes, cutting down of affected trees and mechanical harvesting. Only a few farmers are using insect traps as it is expensive. Figure 8 show types of traps used by farmers in Meru County. In contrast to value chain supporters' information regarding provision of extension services to reduce avocado losses, the farmers mentioned that so far extension services had been provided twice since the start of the year. Interviews with HCD, KEPHIS, and Kaguru Agricultural Training Centre representatives also revealed that extension services are not conducted regularly because of insufficient resources and staffs. All farmers mentioned that extension services are based on farmer driven demand. The farmers mentioned that provision of extension services by extension service providers is only done when there is an increase in pest and diseases. Therefore, farmer to farmer extension is a common way of addressing their challenges. Farmers to farmer extension entails information exchange among farmers based on their experience and innovations.

Figure 8: Types of traps used by farmers (Source: Author, 2022)

iii. Collection

Based on information from the middlemen, it was found out that during harvesting, the middlemen are accompanied by their harvesters, while the farmers usually hire local youths. Collection and bulking are done on by either exporter (30%), middlemen (50%) and brokers (20%). The middlemen sell avocadoes to exporters at KES. 250-400 depending on season. The middlemen also mentioned that sometimes they give money to brokers to harvest and bulk the avocadoes, but trust is an issue. This is because most brokers usually take advantage of the absence of the middlemen therefore do not harvest the right size and quality avocadoes. Recently, the middlemen put on measures whereby the broker harvest then inform the middlemen for collection. Thereafter they are paid according to the number of pieces of quality avocadoes they have collected. According to middlemen, they train brokers on the required quality standards, although it is irregular.

According to interviews with brokers, brokers utilize knowledge of the region to locate avocadoes, negotiate prices with farmers, and assemble enough for the middlemen. According to one of the middlemen respondents "Once we have have assembled enough avocadoes, we notify the middleman for collection." They connect farmers with buyers. They only attempt to put harvested avocadoes under shade. Avocadoes are spread on the ground on top of a layer of banana leaves as illustrated in figure 9.

Figure 9: post-harvest storage and handling of avocado (Source: Author)

Additionally, farmers in the FGD stated that they sell rejects for example overripe, mechanically damaged, and pest and disease infested avocadoes to oil companies, food and beverages companies or distribute to the local community members. The rejects are sold at KES.15-30 per kilogram.

iv. Trading

It was discovered from the interview with Keitt exporters that avocadoes are majorly exported to Europe and Middle East by exporters who act as traders. The respondent also stated that, the middlemen sometimes act as traders since they bulk and sell avocadoes to the exporters based on agreements.

When Keitt exporters representative was asked about losses they incur, he stated: "*Out of 500 crates of 15 kilograms of avocadoes, we incur 50 kilograms of rejects. These rejects include pest and disease infested avocadoes such as rust, FCM, fruit flies and anthracnose, anthracnose, overripe and mechanical damages."* Figure 10 presents avocado rejects in the packhouse awaiting process of oil extraction.

Figure 10: Avocado rejects for oil extraction (Source: Author, 2022)

Towards reducing avocado losses, the exporter stated that they educate farmers on avocado production and management, production, and provision of certified seedling to farmers and conduct field days using their own farms to train farmers. Education of farmers is done in partnership with Kenya Biologics, and Sygenta. Typical topics covered in the trainings include proper use of chemicals, timing of application and pre-harvest interval practices. The trainings are done separately with each partner and contracted farmers. He also mentioned that although they provide extension services to their contracted farmer it is still insufficient.

v. Processing

According to Keitt exporter and Biofarm respondents, it was discovered that exporters process avocadoes. When asked how they ensure reduction of avocado losses at the packhouse, Keitt exporters representative stated that:

"*At the pack house, the avocadoes are weighed, washed, brushed, treated with fungicide in water, brushed, sorted, brushed, sized (12 – 32 fruits/box), and finally refrigerated at a temperature of* 5^0 *C*."

Exporters through interviews complained of receiving consignments of immature avocadoes that instead of ripening they shrink. Interviews with key informants from National Agricultural and Rural Inclusive Growth Project, Meru County Government, Kenya Plant Health Inspectorate Service, Kaguru Agricultural Training Institute and Horticulture crop Directorate revealed that equipments for measuring dry matter and oil content are expensive, which makes it impossible for farmers to determine the maturity levels of

avocadoes. Figure 11 illustrate a sample of equipment that Keitt Exporters were found using for determining avocado quality parameters.

Figure 11: Equipments for determining quality of avocadoes (Source: Author, 2022)

vi. Exporting

Based on interviews with Biofarm and Keitt Exporter, it was gathered that main avocado exporters are Kakuzi PLC, Keitt exporters ltd, Sunrise ltd, East African growers ltd. These companies source avocadoes from individual farmers, producer groups or own plantations. Exporters sell avocadoes to importers at 4 kilograms box, each at KES. 550-650 depending on seasonality. Keitt Exporters representative also mentioned that avocadoes are processed in the packhouses by exporters and sold to importers based on consignments while those that do not meet export market requirements (overripe, mechanical damaged, pest and disease infested) are processed to crude oil and sometimes sold to wholesalers.

vii. Manufacturing (Oil extracting)

Interviewees with Biofarms Limited and Keitt Exporters representative revealed that 5% of exporters have oil extraction machines whereby the rejects are converted to other products such as crude oil. Exporters who do not process rejects, sell to other oil extraction companies or food and beverage companies.

viii. Importing

Keitt Exporters and Biofarms Limited representatives revealed that the main wholesalers are found in Europe, Middle East, and China. Retailers, middlemen and focus group discussion participants stated that the county wholesale markets are majorly Gakoromone and Nkubu market. Based on researcher's observations, these markets are flooded with the local varieties especially Jumbo even though there are a few Hass and Fuerte variety sellers. The wholesaler sells to either the retailers such as kiosks or restaurant buyers.

ix. Retailing

According to Abogeta West Avocado Cooperative representative, 97% of the retailers sell local varieties. The retailers also mentioned that some retailers sell in the open markets, and roadside with small kiosks. Retailers also selling Fuerte and Hass varieties at a local store mentioned lack of storage facilities, immature avocadoes, and poor post-harvest handling as major causes of avocado losses. They sell the hybrid varieties at KES. 10 per piece.

x. Consuming

Representatives from National Agricultural and Rural Inclusive Growth Project, Meru County Government, Kenya Plant Health Inspectorate Service, Kaguru Agricultural Training Institute and Horticulture crop Directorate, Ministry of Agriculture and Livestock, middlemen, exporters and focus group discussion participants confirmed that the Hass and Fuerte variety are majorly produced for export consumers.

4.1.2 Chain supporters and their roles in reducing avocado losses

Stakeholders supporting the avocado value chain and their roles in avocado loss reduction is as shown as shown in the stakeholder matrix in table 3. The following are the supporters involved in the chain.

i. Kenya Plant Health Inspectorate Service (KEPHIS)

Representative from KEPHIS indicated that KEPHIS being a government regulatory agency monitor and educate producers and exporters on avocado production, management, and handling to reduce avocado losses.

"*We issue phytosanitary certificate, issue plant import permit, carry out farm plant health inspection after every 3 months, facility inspection and certification and execute trainings for the exporters on pest and disease management and minimum quality requirements. Even though we are supposed to conduct regular checks, we are not able to do so because of insufficient staffs."*

ii. County Government of Meru

Meru County Government representative revealed that the county government of Meru play different roles in the avocado sub sector in Meru County. Among the roles include provision of extension services to farmers, partner with the community to produce quality seedlings, provision of subsidized seedlings, and linking farmers to market. These ensure reduction of avocado losses.

According to Meru County Government representative: "*Thirty percent of the avocado losses occur at the production stage with False Codling Moth (FCM) being a major pest to the avocadoes especially in the lower regions of Meru. This is because of the favourable conditions for FCM infestation."*

iii. Pest Control and Products Board (PCPB)

From the interview conducted with the officer from Pest control and product Board, the board plays a role in providing advice regarding regulations on use of pest control products.

iv. Kenya Agricultural and Livestock Research Organization (KALRO)

About how to reduce avocado losses, the key informant from Kenya agricultural and livestock research organization revealed that they propagate certified avocado seedlings and sell to farmers at KES. 120, and train farmers on good agronomic practices of avocadoes.

v. Horticulture Crop Directorate (HCD)

From the interview with the HCD representative, it was discovered that HCD is a regulatory body in the agricultural sector whose roles include provision of export license, conduct farm inspection to check adherence towards handling and management of avocadoes and has the register middlemen, mandate to renew farmers contracts.

vi. Avocado society of Kenya (ASK)

HCD and KEPHIS revealed that Avocado society of Kenya plays a role in the reduction of avocado losses by conducting trainings for farmers and exporters of avocadoes on good agricultural practices and organize county farmers day for sensitization.

vii. Meru university of Science and Technology

Interview with the representative of Meru University of Science and Technology revealed that the university play a role in the community by buying certified avocado seedlings in bulk from KALRO and selling to the local farmers and conducting open days for farmers on good agronomic practices.

viii. Kaguru Agricultural Training center

Kaguru Agricultural Training center representative indicated that being a government institution, they train, and capacity build farmers. This is in collaboration with HCD and Meru County field extension officers. It was revealed that farmers who are organized in groups benefit compared to individual farmers. This is because organized groups can be trained as a group and there is exchange of information and experiences among themselves.

ix. Ministry of agriculture, Livestock and Fisheries

Based on interviews with Kaguru Agricultural Training Institute, the Ministry of agriculture, Livestock and Fisheries support farmers implement and monitors policies and regulations.

x. Financial institution

Financial institutions such as Equity Bank and Kenya Commercial Bank provide credit facilities to avocadoes in Meru County. County Government of Meru mentioned that farmer have low collaterals therefore they do not qualify for loans.

xi. Jomo Kenyatta University of Agriculture and Technology (JKUAT)

The key informant from (KALRO) indicated that JKUAT is also responsible for research and improvement of avocado varieties. Through the research they come up with recommended varieties to consider when it comes to production.

4.1.1.1 Avocado Value Chain Stakeholder Matrix

Table 2 and 3 below presents the avocado value chain stakeholders' roles in relation to reducing avocado losses.

Actors	Current roles and functions aimed at reducing avocado losses	Categories
Input dealers	Provision of inputs such as fertilizers and pesticides to reduce pest and diseases in avocadoes carry out soil testing to avocado farmers to provide an accurate assessment of the soils fertility and recommend fertilizer use., Advise farmers on the safe use, handling and pre harvest interval practices of inputs, rates of pesticides and fertilizer application.	Licensed government nursery growers such as KALRO and JKUAT Unlicensed private nursery growers Licensed private Nursery growers i.e. Keitt Exporters
Producers	Adoption of traditional methods of controlling pest and disease such as wood ash, burying method, cutting down of affected trees Farmer to farmer extension services.	Based on FGD participants avocado farmers were categorized as follows with respect to number of trees: Small (1-50 trees) Medium (51-150 trees) Large (151 and above)
Brokers	Harvesting of required size, pedicel length and good physical appearance.	95% are men
Middlemen	Train brokers on harvesting and post-harvest handling of avocadoes	Both men and women
Exporters/ processors	Partner with Kenya Biologics, and Sygenta to educate farmers on avocado production and management Production of certified seedling Conduct field days using their own farms to train farmers.	Avocado exporters include Keitt exporters, Biofarm limited, East Africa Fresh Fruits, Key exporters and Olivado EPZ limited, Kakuzi
Manufacturers	Train farmers and middlemen on good production and management of avocadoes	Oil extractors e.g Solfruit Kenya, Keitt Exporters
Wholesalers	Adoption of post-harvest handling and management practices	Local wholesalers for local varieties International wholesalers for hybrid varieties
Retailers	Adoption of post-harvest handling and management practices	95% are women Include kiosks, supermarkets, and roadside seller

Table 2: Avocado stakeholder Matrix of Meru County

Supporters	Current roles and functions aimed at reducing avocado losses
County Government of Meru	Advocate and promote certified avocado production through subsidization of avocado seedlings Offer extension services e.g., trainings on production, harvesting and post-harvest handling of avocadoes
KALRO	Train farmers on best agronomic practices Provision and supply of certified seedlings Propagation of certified avocado seedlings
HCD (Horticulture Crop Directorate)	Registration of middlemen after monitoring their compliance to quality and safety standards Offer technical and advisory services to farmers and middlemen conduct farm inspection to check adherence towards handling and management of avocadoes
Avocado association of Kenya (ASK)	Offer trainings and capacity building for farmers and exporters of avocadoes on good agricultural practices Organize county farmers day for sensitization. Guide farmers comply with market requirements on food safety and social standards
Kaguru training institute	Train farmers good agronomic practices through farmer field schools through partnership with the County Government of Meru and e - extension. E-xtension services are provided through local media services and internet.
KEPHIS	Conduct inspections to ensure adherence to export quality requirements Offer phytosanitary and safety trainings and certifications
Meru University	conduct open days for farmers where farmers are trained on good agronomic practices provision of certified avocado seedlings
Financial Institutions	Provision of credit facilities
Pest Control and Products Board	Provide advice regarding regulations on use of pest control products.
NARIG project	Supporting farmers by establishment of a packhouse Sensitizing farmers to join groups
JKUAT	Research and improvement of avocado varieties

Table 3:Avocado stakeholder Matrix of Meru County

4.1.1.2 Avocado Value Chain Map in Meru County

Figure 12 depicts the core functions, actors, product flow and information flow of avocado value chain in Meru County, according to the information provided by the key informants and FGD participants. Based on farmers, there is no coordination in money flow as the producers sell to middlemen and exporters per piece while the exporters sell to importers per kilograms. The prices in the chain map were standardized.

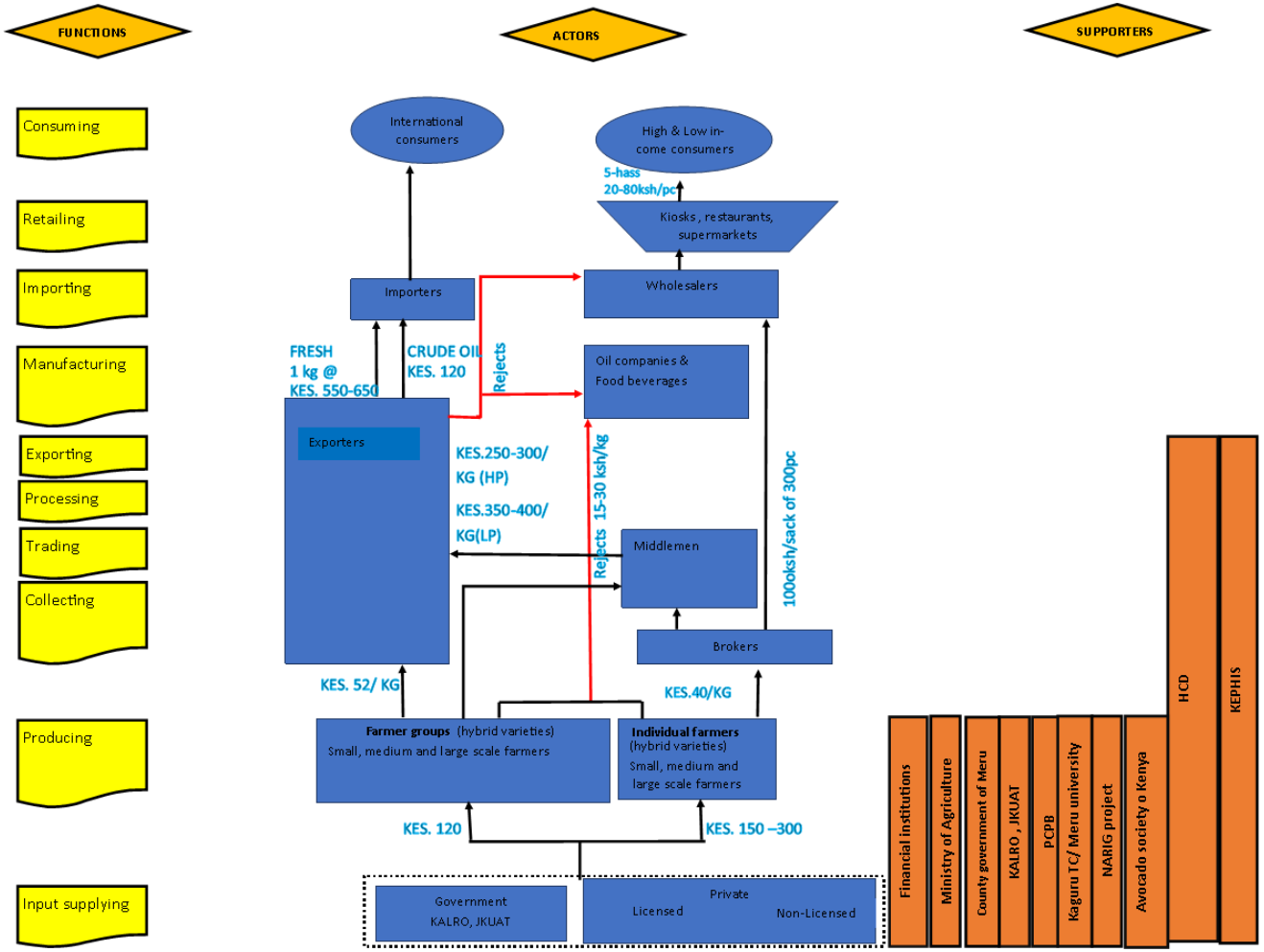

Figure 12: Avocado chain map of Meru County. Adapted from information from respondent

4.2 Performance of chain in terms of stakeholders relations, policy harmonization and product flow towards scaling avocado loss reduction

Stakeholder relations

Keitt Exporters, Biofarm Limited, middlemen, KEPHIS respondents perceived importers to be powerful actors as they are the gateway to a growing avocado market. They mentioned the presence of tough requirements in the international market such as Maximum Residue Level.

Regarding institutional scaling practices, the results showed that there are relatively strong relations between HCD, KEPHIS and farmers but weak relations between HCD and middlemen. KEPHIS and County Government of Meru, revealed that the relationship between Government institutions such as HCD, KEPHIS and farmers is relatively strong. According to middlemen, there is insufficient collaboration among stakeholders, thus resulting to high avocado losses. Additionally, HCD representative stated that there is a tag of war between the local and national government as there is no proper coordination between the two levels of government.

According to focus group discussion (FGD) respondents, there is no clear relationship among farmers, exporters, or middlemen. There are incidences of exporters and middlemen breaching the contract agreements for example late payment. This leads to temporary cancellation of contracts by the farmers thus increased maturation of the avocadoes and late picking. One of the middlemen mentioned that sometimes farmers are hesitant on signing contracts with exporters due to lack of transparency in terms of payments and returns of rejected avocadoes. "*It's just mutual understanding, no written agreements. When it comes to brokers and middlemen, avocado farmers have mixed feelings*." To reduce losses because of over maturity and over ripening, farmers look for other buyers temporarily.

Policy harmonization

According to HCD representative, avocado value chain in Meru County is governed by agricultural policies and regulations at the county and national levels. Policies are set by the National government while the local government oversee that they are adhered to by the actors. There are regulations and guidelines regarding pesticides use, pre- and post-harvest interval, transportation measures and storage systems. However, enforcement of these regulations is poor. There is no regular check on the adherence of the policies by the actors regarding post-harvest handling of avocadoes because of limited resources. According to input suppliers, there is weak policy harmonization on the use of chemicals. Different export companies have different regulations regarding chemicals usage recommendations required by importers.

When HCD representative was asked how they ensure actors adhere to regulations, he stated that: "*Middlemen and exporters adherence to regulations regarding avocado handling is a big challenge. For example, transportation of avocadoes using motorbikes and open-air pickups is common by the middlemen. Actors who are found not adhering to regulations are usually blacklisted*."

Additionally, National Agricultural and Rural Inclusive Growth Project and HCD representatives mentioned that to restrict harvesting of immature avocadoes, HCD in collaboration with Ministry of agriculture put regulations on avocado maturity indices during certain periods of the year, from November to early March. This is to restrict exportation of immature fruits. The time of harvesting is based on Agriculture and Food Authority (AFA) regulations.

Product flow

Based on interviews with all key informants and focus group discussion participants, the following are the 2 main avocadoes channels in Meru County:

Channel 1: Farmer groups or cooperatives sell directly to exporters then to importers. This channel is more organized compared to other channels. Harvesting, aggregation and transportation to packhouse is done by the exporters.

Channel 2: Individual farmers, to middlemen via brokers to exporters then to importers. There are no standard measures that are followed as fruits and packed in polythene bags in uncontrolled temperature vehicles. The channel is preferred by some farmers because of spot on transaction.

4.3 Roles of formal and informal knowledge institutes in avocado loss reduction

Kaguru Agricultural Training center representative mentioned that Kaguru Agricultural Training center partner with other stakeholders for example HCD, and County Government to train and capacity build avocado farmers in Meru County towards good agronomic practices for example, land preparation, planting, pest, and diseases management. Through trainings, farmers are usually advised to join common interest groups. In an interview with the Abogeta West Avocado Cooperative representative, it was discovered that the adoption rate of the skills and knowledge acquired is still low.

In an interview with Meru University key informant, it was discovered that Meru University of Science and Technology conducts open days for farmers to train on good agronomic practices and management. Meru University of Science and Technology also plays a role in the provision of certified avocado seedlings to farmers within the community. County Government representative mentioned that JKUAT also carry out research and development of high yielding and quality avocado seedling varieties.

4.4 Roles of support services towards reducing avocado loss reduction

In the avocado value chain in Meru County, the current support services that were identified to target avocado loss reduction are the (NARIG) project, Agriculture Sector Development Support Program (ASDSP) and Kenya Climate Smart Agriculture Project.

From the interview with NARIG project representative and focus group discussion participants, (NARIG) project is establishing a packhouse to enhance the reduction of avocado losses. Through the project the farmers are also sensitized to join common interest groups so that they can benefit from the pooled resources such as extension services, and processing plants. According to key respondent from NARIG project and focus group discussion participants, to reduce avocado losses, avocado farmers in groups benefit from extension services from different supporters within the chain. The representative of the NARIG project stated that:

"*NARIG project was started in 2018 among the 47 counties in Kenya with Meru County prioritizing banana, irish potatoes, avocadoes, and macadamia value chains. The selection of the value chains was based on potential for growth, competitiveness in terms of yields and gross margins, social inclusion, nutrition sensitivity and resilience to climate change. Through the project, establishment of an avocado packhouse in Meru County is underway and is expected to be ready by end of 2023. This is to reduce avocado losses along the chain.*"

According to the representative from County Government of Meru, "*NARIG project partnered with Agriculture Sector Development Support Program (ASDSP) to provide advice to farmers on anticipated weather condition at the beginning of the season."* According to KALRO key informant Kenya Climate Smart Agriculture Project aims to increase agricultural output and build resilience to climate change risks.

4.5 Current technical practices for scaling avocado loss reduction

The practice was discovered to be widely scaled in Meru County as a practice for reducing immature harvesting of avocadoes. Regulations regarding harvesting periods was affirmed to facilitate reduction of avocado losses. All interviewees recognized the Agriculture and Food Authority (AFA) regulations on maturity index as an important aspect in the reduction of immature harvesting of avocadoes. The adoption rate of these regulation is high because of restricted exportations.

Another current practice mentioned by key informants and FGD respondents is the use of certified seedlings to scale avocado loss reduction. Farmers in the FGD and individual farmers stated that they are now replacing the traditional avocado trees with certified avocado trees. This was also reiterated by Abogeta West Avocado Cooperative representative who mentioned that the farmers are starting to plant certified avocado seedlings.

The findings show that currently application of pesticides is only limited to large scale farmers but not scaled to small scale farmers. Pesticide regimes recommended by importers are highly used and followed by large scale farmers as compared to small scale farmers. According to Abogeta West Avocado Cooperative representative, farmers lack of motivation is a major barrier to the adoption rate of pesticides application. The farmers use traditional methods of controlling pest and diseases. Representative from HCD and Meru Avocado Champions revealed. "HCD and KEPHIS carry out inspections to monitor adherence to regulations and phytosanitary procedures by the farmers, middlemen, and exporters. Although the inspections are not regular. Majority of the pest and diseases are quarantine pests, therefore when there are rising cases of infestation in the areas, the authorities get involved."

Manual harvesting was discovered to be use by majority of the farmers. According to FGD respondents, 97% of the farmers harvest avocadoes manually. "*Most farmers do not possess harvesting tools. Therefore, they hire youths who climb on the trees to harvest. The local boys are used as harvesters. We still incur losses caused by mechanical damage, broken stalks, bruises, overripe, undesired size, and harvesting of immature avocadoes from the harvesters. Maturity is determined by visual observation of the appearance of the avocadoes such as skin color, and texture while for the exporters they use equipments and machines to determine the moisture content, dry matter, and sizes. These equipments and machines are expensive.*"

From an interview with one of the middlemen, crates were used for transportation it was discovered that few brokers and middlemen use packaging materials such as crates for transportation as most of them transport avocadoes in open air vehicles. However, the practice is not scaled to other brokers and middlemen. Most of them lay down banana leaves on vehicles then avocadoes are heaped to reduce the mechanical damages and bruises.

Based on the interview with Biofarm limited and Keitt Exporters, it was realized that precooling and cold storage was used as a practice for scaling avocado loss reduction. Biofarm limited and Keitt Exporters representatives revealed that once avocadoes reach packhouse they are pre-cooled to remove field heat and stored in temperature-controlled environments. On the other hand, brokers revealed that they leave

avocadoes in the fields for about 2-3 days before collection by middlemen because of lack of storage systems.

KALRO representatives mentioned that currently there are established knowledge and innovation platforms for example mobile Applications that are used to help farmers in the production of different crops, avocado being one of them. "*KALRO selector app gives step by step information on how to manage avocadoes such as planting, harvesting, marketing and how to identify and control pest and disease. The organization is trying to promote and provide timely high-level research and advise to farmers on best agronomic practices. Before the intervention of internet infrastructure, we could spend a lot of time and incur huge travelling and phone call costs in disseminating information unlike now*." Additionally, Abuduguchi Organic Avocado Growers representative mentioned the use of WhatsApp as a means of information exchange. However, the use of this Apps is not scaled to farmers.

4.6 Current methodological practices for scaling avocado loss reduction

All interviewees mentioned that training and capacity building play a crucial role in scaling of avocado loss reduction. The actors especially farmers are trained by different stakeholder such as KEPHIS, Meru County extension officer, Meru University, Kaguru Agricultural Training Institute, and HCD. The trainings are usually on good agronomic practices and quality standards. HCD key informant also reiterated that middlemen, brokers, and farmers are sensitized on pre harvest and post-harvest management of avocadoes. When asked types of trainings that they received, the FGD participants answered by saying: "*Sensitized on the recommended use of chemicals, timing of application, pre harvest interval practices and post-harvest handling of avocadoes. This is usually carried out by extension officers, KEPHIS and HCD*." According to Abogeta West Avocado Cooperative the level of adoption of the skills and knowledge acquired through trainings is low because of lack of motivation, age, and attitude.

Kaguru Agricultural Training Institute representative pointed out that extension services are usually farmer driven. Provision of extension services is only carried out on farmer demand. This is because of insufficient extension service providers. Kaguru Agricultural Training Institute representative mentioned that farmers are usually advised by the NARIG project to join farmer groups where they can benefit from joint services. Farmer to farmer extension services was also stated as a method for scaling avocado loss reduction by FGD respondents. The FGD respondents said that: "*When we meet as a group, there are usually issues on avocado production and management that arise, and based on different farmers experiences on tackling them, we usually end up with control measures that others have already tried out. Therefore, farmers are encouraged to join groups where they can share knowledge and experiences*."

Kaguru Agricultural Training Institute, HCD, NARIG project representatives indicated that, organization of farmers in groups is advantageous as they can acquire resources such as subsidized avocado seedlings, trainings, and capacity building, fundings, and market easily unlike individual farmers. According to middlemen, NARIG project, and Abogeta West Avocado Cooperative representatives, there are various existing avocado farmer groups such as Mugamboni Fruits and Nuts Supplies, Abogeta West Avocado Cooperative, Abuduguchi Organic Avocado Growers, and Meru Avocado Growers.

PPPs was also identified as a method that facilitate reduction of avocado losses. Various PPPs between the avocado stakeholders were identified to reduce avocado loss reduction by Kaguru Agricultural Training Institute representative.

Additionally, key informant with Kaguru Agricultural Training Centre representative revealed that farmer field schools (FFS) are used for training and capacity building of farmers on avocado production and management practices. The practice is limited to farmers organized in groups but not scaled to individual farmers. "*The County Government of Meru in partnership with National Agricultural and Rural Inclusive Growth Project (NARIGP) kicked off a farmer field school targeted at teaching farmers on good agronomic practices, harvesting and handling of avocadoes*."

Abogeta west Avocado Cooperative informant also mentioned that there is manual traceability system in Meru County avocado value chain. To scale avocado loss reduction, traceability is carried out by exporters. Tracking of avocadoes from source to importer is carried out to reduce cases of losses along the chain. To ensure traceability at the farmers level, harvesting date, time, variety, farmers name and the farm block in case of different blocks of farm are recorded.

4.7 Enabling and disenabling environments in scaling avocado loss reduction

Key informants from NARIG project, Abogeta West Avocado Cooperative, County Government of Meru, middlemen and exporters revealed that avocado production is increasing due to high revenues and increased demand of international markets. It was also discovered that replacement of avocado with other cash crops such as tea, coffee and miraa is increasing because of high revenues and export demand. It was revealed that development partners are investing in Meru County avocado value chain.

Expansion of avocado market was revealed as an opportunity for scaling avocado loss reduction by Keitt Exporters, middlemen, Abogeta West Avocado Cooperative, County Government of Meru and NARIG project representatives. It was mentioned by Kaguru Agricultural training institute key informant that through linkages via County Government of Meru, there was establishment of markets in Slovakia and China. This stimulated collaboration of actors, supporters, and funded program to develop the avocado chain. For example, NARIGP project funded by World Bank was started with one of the goals of establishing a packhouse for avocado farmers in Meru County and organizing farmers into groups.

Various key informants and FDG respondents mentioned that the production calendar crafted by the National Government is important as it limits harvesting of immature avocadoes. When asked about policies that facilitate reduction of avocado losses, Abogeta West Avocado Cooperative representative responded by stating:

"*Avocado harvesting time is based on AFA regulations. Different regions have different harvesting periods of avocadoes. Meru County avocadoes are usually ready for market from June to August when the seasons in other geographical areas has ended. Minor harvesting season is usually in December and January. Permission must be granted by the authorities before exporting. This is to limit exportation of immature fruits*."

From the interviews with the farmers, middlemen, brokers, and exporters it was discovered that poor means of transport such as non-refrigerated containers, low levels of use of crates is a barrier to scaling of avocado loss reduction. Although actors are trained on the importance of proper packaging, less than 5% adopt the methods. Middlemen are fond of using banana leaves to act as a soft surface before heaping the avocadoes onto trucks. Sometimes the avocadoes are put in polythene bags for transportation to warehouse.

Through an interview with the broker, it was discovered that there is lack of storage systems. The informant mentioned that after harvesting the avocadoes, they are put on banana leaves under a shade for 2-3 days waiting for collection by the middlemen. Unlike individual farmers, farmers groups sell directly to exporters. The exporter hires harvesters with the supervision of the agronomist, collect, bulk then transport to packhouse.

According to all key informants and FGD participants high incidence of diseases and pests such as False Codling Moth, fruit flies, anthracnose, and rust are threats to scaling of avocado losses. Pest and diseases affected the quality of avocadoes thus high rejects occur. Insufficient extension services were mentioned as a disenabling environment for scaling avocado loss reduction by all interviewees.

The table below presents the current strengths, weaknesses, opportunities, and threats enabling or disenabling scaling of avocado loss reduction.

Strengths	**Weaknesses**
High revenues Availability of high quality and high yielding avocado seedling varieties Production calendar crafted by the National Government on the harvesting periods based on different avocado growing regions	Poor transportation methods Poor storage systems Lack of equipments for harvesting and determining maturity, storage
Opportunities	**Threats**
Expansion of new markets country wide and internationally such as Slovakia, China, and Europe. Supportive development partners such as World Bank through NARIG project	High incidence of diseases and pests Insufficient extension services

Table 4: Avocado SWOT Analysis in Meru County

CHAPTER 5: DISCUSSION

5.1 Roles of chain actors and chain supporters in avocado loss reduction in Meru County

This study identified various actors and supporters operating various core chain functions and providing support services in the avocado chain in Meru County.

At input supplying, the study revealed that majority of farmers use uncertified avocado seedlings acquired from local nursery growers as opposed to certified growers. This revelation entails that farmer end up propagating avocado trees that are susceptible to pest and disease which eventually lead to enormous pre and postharvest loses. Although there exist formal input suppliers with capacity to provide certified seedlings, a considerable number of small-scale growers still obtain their seedlings from informal channels. This might be explained by the fact that farmers have inadequate financial capacity to afford certified planting materials. Furthermore, the existing input suppliers in the chain were found providing extension support to farmers but this does not appear to motivate farmers in Meru to acquire the right planting materials. It is thus evident that the financial constraint appears to be a greater hindrance towards loss reduction in Meru.

The study revealed that 90% of the avocado producers in Meru were small-scale farmers whose management of avocado farms is dependent on use of family labour supplemented with casual workers. This finding might imply that farmer's commitment to implementing avocado loss reduction practices maybe constrained by labor availability. Some studies have attributed high losses among smallholders to availability of farm labor (Migose., 2018.). Coupled with labour constraint, efforts to reduce losses among avocado producers in Meru seems to be compounded by inadequate extension services. This is in line with the study of Altalb et al., (2015) who postulated that insufficient extension to farmers has a positive contribution to high pre- and postharvest losses incurred at production. However, the author further argues that adoption of best practices for avocado loss reduction is lacking among avocado producers in Meru County. Based on author's observation, this might be because majority of small-scale producers in Meru's avocado value chain are old, and as some studied have confirmed, aged farmers tend to be slow adopters of new technologies as they are afraid of risks associated with taking up new practices (Altalb et al., 2015).

The study further revealed that middlemen and brokers are the main collectors of avocadoes from farmers and supply to exporters in the chain. Thus, they form the link between the farmers and exporters in the chain. From the authors point view, middlemen and brokers contribute to losses currently being incurred in the chain due to lack of proper post collection and handling practices. This was reflected in the comments of exporters who lamented incurring losses due to receiving mechanically damaged avocados from collectors.

Based on the findings of this study, it has been noted that producers and collectors in the avocado value chain in Meru are not doing enough to prevent pre-harvest, harvest and handling related losses of avocado, and this results in huge losses of avocado to be incurred at production and transportation phases of the value chain. As stated earlier, these actors appear not to be properly capacity built in avocado handling which render their roles in avocado loss reduction almost insignificant. Studies have shown that the way a product is handled at harvesting and immediately after will to large extent determine its postharvest shelf life. Interestingly, other actors up in the chain, particularly exporters, manufacturers, wholesalers, and retailers claimed to provide extension and training support to producers being the principal source of the product for their bushiness. However, this does not seem to reflect the current situation of producers in Meru County.

5.1.2 Chain supporters and their roles in reducing avocado losses

This study identified an elaborate list of supporters playing various roles in the avocado value chain of Meru County. However, this study has also demonstrated that the common role played by all the identified supporters in avocado loss reduction is basically limited to extension and training of farmers. However, this support role is neither adequately provided to producers nor meeting their collective needs. This is because majority of supporters interviewed such as the Kenya Plant Health Inspectorate Service (KEPHIS) and the County Government of Meru lamented the problem of insufficient staff. This means that producers in the value chain do not receive regular training and extension support. Although the supporters of the value chain partner with the community to produce quality seedlings, provide subsidized seedlings, and link farmers to markets to ensure reduction of avocado losses, majority of farmers do not appear to benefit fully from the support initiatives.

The author is of the view that producers in Meru County are lacking motivation in terms of other forms support such as financing to improve farmers access to quality inputs, equipment and machinery that can improve avocado production and quality. Although financial institutions such as Equity Bank and Kenya Commercial Bank provide credit facilities to avocado growers in Meru County, majority of farmers do not have collaterals to enable them to qualify for loans. Therefore, value chain support functions focused solely on improving farmer's knowledge without providing an enabling environment for adoption and application of that knowledge may not achieve the desired outcome of reducing avocado losses in the chain.

5.2 Performance of chain in terms of stakeholders relations, policy harmonization and product flow towards scaling avocado loss reduction

Stakeholder relations

This study has shown that the relationship between middlemen and HCD is not strong as many middlemen do not usually adhere to regulations. Additionally, there is no proper coordination between the two levels of government. Further, there exist no clear relationship among farmers, exporters, or middlemen, exporters due to lack of transparency in terms of payments and returns of rejected avocadoes. This situation has dire implications to stability and performance of the chain. This is because promoting the performance of the avocado value chain so that it effectively meets the demands of international market requires collaboration among stakeholder within the avocado value chain, both private and public sectors. According to Bamber et al. (2011), chain stakeholders' coordination and collaboration is key in chain performance and upgrading.

In Meru's avocado value chain, untrustworthy relationship between brokers, middlemen and farmers might lead to cheating and compromise quality standards. This is line with Matui et al. (2016) who identified that weak relations in the supply chain contribute to high price fluctuations and high incidence of food loss in the Kenyan fresh vegetable. Transparency is critical to developing trust and long-lasting relationships among actors. However, this seems to be lacking among actors in Meru's value chain. Lack of trust and transparency is likely to undermine chain governance which is critical to avocado loss reduction. This is because an uncoordinated chain is likely to lose its integrity and might affect business to business interaction among actors. Further, this might lead to small-scale producer's lack of capacity to improve accountability and quality of the avocados in the value chain.

Policy harmonization

The study showed that poor coordination between the national and county government characterize the avocado value chain in Meru. As the research showed, there is limited enforcement of avocado quality regulations as there is no regular check on adherence to the policies by the actors regarding pre-harvest and post-harvest handling of avocadoes. This situation is attributed to limited resources available for the authorities to perform this function. This may lead to policy harmonization challenges that may affect service delivery and further exacerbate institutional causes of losses. Snel et al. (2020) state that effective and sustainable post-harvest loss reduction requires sector-wide, bundled approaches whereby private and public sector organizations collaborate to jointly advance and professionalize the sector. However, this is unlikely to happen in the avocado sector of Meru County unless the inadequate policy harmonization observed by this research is robustly addressed.

5.3 Roles of formal and informal knowledge institutes in avocado loss reduction

This research has shown that there exist several formal knowledge institutes in Meru County to provide technical knowledge and support to avocado growers. These institutions train and capacity build avocado farmers in Meru County towards good agronomic practices such as land preparation, planting, pest and diseases management, and in the provision of certified avocado seedlings to farmers within the community. Like other supporters of the value chain as earlier stated, these knowledge institutes focus on providing technical knowledge and training to farmers. However, there is a gap in appropriate knowledge transfer approaches that not only impart knowledge and skills but also motivate farmers to adopt them. Ultimately, it is the adoption of avocado loss reduction practices that count. Much as the available institutes develop and transmit technologies, there is need for approaches that demonstrate practical application of such technologies to farmers.

The extension service providers have recommended use of the farmer field schools, an approach which the researcher strongly agrees with. According to Neufeldt et al. (2015), various extension approaches such as farmer to farmer and farmer field school, and rural resource centers assist in spreading innovations. This approach, along with others such as field days, promote location-based transfer of technologies with impact. As postulated by Matui et al., (2016), collaboration between research and knowledge organizations with domestic market actors is required to begin creating examples of success and models around which the sector can grow. Matui et al. (2016), added that actors are increasingly understanding the need to engage with research and knowledge organizations. This is proved by the attendance of farmers at farmers field days.

Interestingly, the research did not find well recognized informal knowledge institutions based on information from respondents. However, the author argues that there are several existing farmer organizations, interest groups and cooperatives which suffice to be channels for knowledge dissemination within local communities. It appears that these local based institutions are not championing knowledge transfer and farmer-to-farmer learning initiatives for avocado loss reduction among their members. Considering the challenge of inadequate extension services provided by government and private extension, these local-based institutions can play a pivotal role in promoting adoption of loss reduction practices among their members.

5.4 Roles of support services towards reducing avocado loss reduction

In the context of this study, support services include projects and programs supported by government, NGOs and donors targeting to reduce avocado losses in the target area. This research found that Meru County benefits from the NARIG project that was found establishing an avocado packhouse. The Agriculture Sector Development Support Program and Kenya Climate Smart Agriculture Project also played the role of advising on weather patterns farmers and increasing productivity and building resilience to climate change risks. Within the scope of this study, these were the known projects implementing initiatives towards avocado loss reduction among actors in the chain.

Interestingly, the full knowledge and awareness about the roles and support functions of the above-mentioned projects was more among supporters than actors of the Meru avocado value chain. For example, farmers were aware of the NARIG project but expressed ignorance about the Agriculture Sector Development Support Program and Kenya Climate Smart Agriculture Project. This lack of awareness might exclude some actors from fully benefiting from the services offered by the services intended to for them. Consequently, these actors are likely to lose opportunities to improve their knowledge and skills required for avocado loss reduction.

5.5 Current technical practices for scaling avocado loss reduction

This study has found implementation of actor-specific technical practices for scaling avocado loss reduction among actors in Meru's avocado value chain. These included proper harvest practices at producer level, and temperature-controlled processing, storage and transport at processing and export level. It is worth noting that actors at producer level were found adhering more to harvest practices such as proper harvest timing and harvesting methods than to pre-harvest operations. This is because of strict regulations put in place by the AFA regarding maturity indices. In addition, farmers fear the risk of their avocados being rejected by the buyers because of poor harvest methods or immature harvesting of avocado. According to Keiya (2014), harvesting should be carried out as carefully as possible to minimize mechanical injury such as scratches, punctures, and bruises to the crop. According to Ramírez et al. (2019), manual harvesting causes much less mechanical damage to the fruits.

In the context of avocado in Meru County, manual harvesting has proved to be an efficient and effective way of reducing avocado losses as minimum mechanical damages occur. However, the author is of the view that similar strict regulations should be implemented during pre-harvest operations not only to reduce production related loses but also to boost productivity of avocados among producers. Furthermore, it is worth noting that actors at processing, exporting, and retailing levels are performing well regarding implementation of loss reduction technical innovations. This might be explained by the fact that these actors are subjected to strict local and international export market requirements that dictate specific product quality. Consequently, these tight market demands force these actors to source and collect well harvested and sorted avocados from producers.

On the other hand, producers and middlemen do not feel subject to such strict regulations during their operations. Despite sensitization and regulations put by regulatory authorities towards packaging and transportation of avocadoes, the rate of adoption is still low. The findings show that means of transportation of avocadoes is poor. Avocadoes are heaped and transported in open air vehicles. The use of crates during transportation is still low. Keiya (2014) stated that proper packaging is essential to maintain the freshness. The study also revealed poor storage systems as a challenge. Harvested avocadoes are left on the fields for long without proper care. This is because of lack of storage systems thus high

losses. Lack of packhouse for aggregation, processing and cooling is also a challenge. There is no equipment and machines for value addition of avocado in Meru County. Matui et al. (2016), noted that poor road conditions packaging, and lack of cooling facilities, contribute to damage of produce during transport. This highlights the need to promote producer certifications such the GLOBAL GAP certifications to encourage producers adhere to recommended technical practices that result in loss reduction and quality improvement.

5.6 Current methodological practices for scaling avocado loss reduction

One of the major findings of the study regarding methodological practices concerns trainings and education of actors. An analysis of the technical practices for scaling avocado losses reveals various practices that are currently used. Trainings and education were found out to be a common method of sensitizing and capacity build actors along the chain. These include correct use of chemicals and harvesting methods. Majority of stakeholders use trainings as a method of scaling avocado loss reduction although it is insufficient. Actors, especially farmers, still lack knowledge about appropriate production systems. Matui et al. (2016), noted that there is always a disparity between the sector's needs and what extension services can provide for commercial and high-tech horticulture farmers.

Extension services such as farmer to farmer extension and farmer field schools are the methods currently used by actors especially farmers in the scaling of avocado loss reduction. This is because of insufficient extension services. Formation of farmer groups has also scaled reduction of avocado losses. Actors especially farmers can negotiate for prices and acquire pooled market. Lack of knowledge by the actors on the importance of collective actions is a major challenge that needs to be addressed to reduce avocado losses along the chain. The findings also reveal an increase in innovation platforms where information exchange occur. Actors within the chain can exchange information faster and easily at a low cost.

Traceability is also an important aspect that is currently being used in the scaling of avocado losses in Meru County. Actors and supporters along the chain can trace back avocadoes from production to inception stage. However, traceability is still at its developing stages. Similarly, the study of Gachukia (2016), revealed that Kenya has been struggling with the issues of traceability, and quality for many years in its export sector partly due to multiple actors.

5.7 Enabling and disenabling environments in scaling avocado loss reduction

Regarding enabling and disenabling environments in scaling avocado loss reduction, this study has revealed various enabling factors in scaling avocado loss reduction. High revenues, availability of high quality and high yielding avocado seedling varieties, presence of harvesting calendar, expansion of new markets country wide and internationally such as Slovakia, China, and Europe and increased development partners as enabling factor in the scaling of avocado losses.

Pest and diseases are another barrier to scaling of avocado losses as found from the study. The farmers are using traditional methods of controlling pest and diseases such as ash. Insufficient extension service providers have been found to be a barrier to scaling avocado loss reduction. Provision of extension services is not regular despite the challenges various actors are facing. Since avocado production is increasing due to high revenues and increased demand of international market, there is need for policy regimes to promote enabling environment for implementation and scaling of the available practices to reduce loses.

5.8 Reflection

The qualitative method of data collection and analysis was effective as in-depth information was acquired from different key informants and FGD participants involved in the avocado value chain in Meru County. The snowball method of sampling was also effective and efficient as more respondents relevant to the study were included. More information relevant to the research was acquired. This enhanced triangulation of the findings from different sources. However quantitative method would have increased the validity and credibility that were mentioned regarding adoption rates of the practices identified. This study has found implementation of actor-specific practices for scaling avocado loss reduction which depends on capability.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This research was conducted with an aim of identifying, analyzing, and developing interventions targeting to promote the implementation and utilization of best practices for reducing avocado losses among actors in Meru County. Based on the research findings and discussion, this chapter answers the main research questions and sub-questions.

This study has shown that the role of governance in Meru's avocado value chain is weak at promoting best practices for avocado loss reduction. From the findings, actors' role in reducing avocado losses was found to be insufficient as it is only limited to adhering to certain technical practices for avocado loss reduction. For producers, their role was limited only to good harvest practices but neglect preharvest practices. This results in high losses occurring at production level. Processors and exporters adhere to processing, storage, and transportation practices. Supporters' roles are only limited to extension and training of actors who are mostly producers. The supporters are not doing enough in providing other form of support such as inputs, equipments and machines for harvesting, processing, and storage. The findings further show that there is insufficient vertical and horizontal coordination and collaboration among actors and supporters to adequately scale up avocado loss reduction. Furthermore, there is a weak chain relationship between actors and supporters to coordinate efforts targeting to scale up loss reduction. In terms of policy, there exist lack of harmonization and enforcement of policies for loss reduction among supporters at national and county level. The existing formal institutions and support services are focused on providing knowledge and skills but do not facilitate for actual adoption of loss reduction technologies among actors.

Secondly, the research has revealed that the current mechanisms for avocado loss reduction in Meru's avocado value chain are inadequate. There is limited implementation of technical and methodological practices for scaling up avocado loss reduction. The technical practices for scaling avocado losses vary according to the actor's capability. The findings reveal that some practices are already adopted by actors while others are less or totally not adopted. The research has shown that the current technical practices including proper time of harvesting by the producers and well implemented storage of avocadoes at the processing stage. However, use of certified seedlings, pesticides regimes, and transportation methods are not well established and implemented. Methodological practices such as extension services, trainings and private public partnerships are used to scale avocado loss reduction. However, these are not sufficiently provided to the actors and thus much more is needed to address the scaling of avocado loss reduction along the chain. Expansion of international markets, increased development partners and high revenues are enabling factors which were identified to enhance scaling of avocado loss reduction. Disenabling factors include poor transportation methods, poor storage systems, lack of equipments for harvesting and determining maturity, high incidence of diseases and pests and insufficient extension services.

6.2 Recommendations

Based on findings, discussion and conclusion, the following are recommendations for scaling avocado loss reduction in Meru County:

I. Scale up training of avocado farmers by use of avocado demonstration plots. This can be achieved by use of avocado demonstration plots of lead farmers.
II. Establishing a financing arrangement/scheme between actors and financing institutions to enable actors access inputs, equipment, and machines for avocado loss reduction.
III. Establishing a multistakeholder platform between actors, supporters, and service providers to enhance chain coordination, partnerships, and policy harmonization.

6.2.1 Theory of change for proposed interventions

The table below shows the actionable detailed plan for the proposed recommendations. The table presents the activities, required inputs, stakeholder involved, how often and where the activities will take place.

Activities	How	Inputs	Who	where	When	Outputs	Outcome	Impact
Training of farmers in best agronomic practices	Setting up avocado production demonstration plots with lead farmer	Land, fertilizer, pesticides, herbicides, certified seedlings, planting equipments, labour Venue Training materials Human resource	Ministry of Agriculture, County government of Meru, HCD, KEPHIS, avocado farmers	Lead avocado farmer fields	5 years	Increased practical knowledge and skills of producers	Increased adoption of best agronomic and technical practices for loss reduction	Reduced avocado Losses Increased income
Increasing actors access to inputs, equipments and machine for avocado loss reduction	Establishing a financing arrangement/ scheme between actors and financing institutions	venue	Meru county government, Abogeta Cooperative, FOGALB project, farmers, middlemen	Abogeta West Avocado Cooperative	5 years	Increased access to finance for inputs, equipment, and tools for scaling avocado loss reduction	Reduce avocado losses	Increased income
To enhance chain coordination, partnerships, and policy harmonization	Establishing a multistakeholder platform between actors, supporters, and service providers	Conference room, writing materials	FORQLAB Project, Cooperative, Meru County government, Ministry of Agriculture	Meru County	5 years	Multistakeholder platform established and operational	Improved actor relation and chain coordination	Improved governance for avocado loss reduction

Table 5: Theory of Change for proposed interventions (Source: Author, 2022)

REFERENCES

Abbott, K.W. and Snidal, D., 2021. The governance triangle: Regulatory standards institutions and the shadow of the state. In *The Spectrum of International Institutions* (pp. 52-91). Routledge.

Altalb, A.A.T., Filipek, T. and Skowron, P., 2015. The role of agricultural extension in the transfer and adoption of agricultural technologies. Asian Journal of Agriculture and Food Sciences, 3(5).

Aggarwal, P.K., Jarvis, A., Campbell, B.M., Zougmoré, R.B., Khatri-Chhetri, A., Vermeulen, S.J., Loboguerrero, A.M., Sebastian, L.S., Kinyangi, J., Bonilla-Findji, O. and Radeny, M., 2018. The climate-smart village approach: framework of an integrative strategy for scaling up adaptation options in agriculture.

Anderson I 2012. Scaling development results. A literature review and implications for Australia's aid program. AusAid, Canberr.

Arpaia, M.L., Collin, S., Sievert, J. and Obenland, D., 2015. Influence of cold storage prior to and after ripening on quality factors and sensory attributes of 'Hass' avocados. Postharvest Biology and Technology, 110, pp.149-157.

Ayala Silva, T. and Ledesma, N., 2014. Avocado history, biodiversity and production. In Sustainable horticultural systems (pp. 157-205). Springer, Cham.

Ayala-Zavala, J.F.N., Vega-Vega, V., Rosas-Domínguez, C., Palafox-Carlos, H., Villa-Rodriguez, J.A., Siddiqui, M.W., Dávila-Aviña, J.E. and González-Aguilar, G.A., 2011. Agro-industrial potential of exotic fruit byproducts as a source of food additives. Food Research International, 44(7), pp.1866-1874.

Balogh, P., Bai, A., Czibere, I., Kovách, I., Fodor, L., Bujdos, Á., Sulyok, D., Gabnai, Z. and Birkner, Z., 2021. Economic and social barriers of precision farming in Hungary. Agronomy, 11(6), p.1112.

Bebe, B.O., Rademaker, C.J., van der Lee, J., Kilelu, C.W. and Tonui, C., 2017. Sustainable growth of the Kenyan dairy sector: a quick scan of robustness, reliability and resilience: executive summary (No. 1021). Wageningen Livestock Research.

Bereda, S., 2016. Effect of harvesting, handling and storage techniques on quality and shelf life of avocado fruits in Sidama Ethiopia. School of plant and horticultural science, College of agricultural, p.72.

Bertin, T., Zacharie, T., Ann, D., Ebenezar, A. and Alain, T., 2014. Scaling-up sustainable land management practices through the concept of the rural resource centre: reconciling farmers' interests with research agendas. The Journal of Agricultural Education and Extension, 20(5), pp.463-483.

Bill, M., Sivakumar, D., Thompson, A.K. and Korsten, L., 2014. Avocado fruit quality management during the postharvest supply chain. Food Reviews International, 30(3), pp.169-202.

Boulding A, Devine R 2019.Evaluation of Framework for Action pilots – Final Synthesis Report D2.8.

Bustos, C.A. and Moors, E.H., 2018. Reducing post-harvest food losses through innovative collaboration: Insights from the Colombian and Mexican avocado supply chains. Journal of Cleaner Production, 199, pp.1020-1034.

Cadilhon, J.J., 2013. A conceptual framework to evaluate the impact of innovation platforms on agri-food value chains development.

Coe, R., Sinclair, F. and Barrios, E., 2014. Scaling up agroforestry requires research 'in'rather than 'for'development. Current Opinion in Environmental Sustainability, 6, pp.73-77.

Delgado, L., Schuster, M. and Torero, M., 2017. Reality of food losses: A new measurement methodology.

Dengerink, J. and van Rijn, F., 2018. ITC's contribution to export competitiveness and farmer livelihoods: Verification of ITC's intervention logic in the avocado sector in Kenya: final report July 2018 (No. 2018-047). Wageningen Economic Research.

Donetti, M. and Terry, L.A., 2014. Biochemical markers defining growing area and ripening stage of imported avocado fruit cv. Hass. Journal of Food Composition and Analysis, 34(1), pp.90-98.

Endalew, E., 2020. Postharvest Loss Assessment of Tomato (Lycopersicon esculentum Mill) (Galilea Cultivar) along the Postharvest Supply Chain, Northwest Ethiopia (Doctoral dissertation).

Erkan, M. and Dogan, A., 2019. Harvesting of horticultural commodities. In Postharvest technology of perishable horticultural commodities (pp. 129-159). Woodhead Publishing.

FAO, 2011. Global Food Losses and Food Waste – Extent, causes and prevention, Food and Agriculture Organization of the United Nation, Rome. Availabe at http://www.fao.org/docrep/014/mb060e/mb060e. Accessed :21/4/2022.

FAOSTAT. Agricultural production data. 2020. Available at http://www.fao.org/faostat/en/#data/QC. Accessed: 21/5/2022

Franzel S, Degrande A, Kiptot E, Kirui J, Kugonza J, Preissing J, Simpson B. 2015. Farmerto-farmer extension. Note 7. GFRAS Good Practice Notes for Extension and AdvisoryServices. Global Forum for Rural Advisory Services (GFRAS): Lindau, Switzerland. Available at: www.g-fras.org/en/ggp-notes/farmer-to-farmer-extension.html. Accessed:2/6/2022

Gakuubi, M. M., & Wanzala, W. 2012. A survey of plants and plant products traditionally used in livestock health management in Buuri district, Meru County, Kenya. Journal of Ethnobiology and Ethnomedicine, 8(1), 39.

Gebreyes, M., Mekonnen, K., Thorne, P., Derseh, M., Adie, A., Mulema, A., Kemal, S.A., Tamene, L., Amede, T., Haileslassie, A. and Gebrekirstos, A., 2021. Overcoming constraints of scaling: Critical and empirical perspectives on agricultural innovation scaling. PloS one, 16(5), p.e0251958.

Geels, F.W., 2019. Socio-technical transitions to sustainability: a review of criticisms and elaborations of the Multi-Level Perspective. Current opinion in environmental sustainability, 39, pp.187-201.

Ghiron, L., Shillingi, L., Kabiswa, C., Ogonda, G., Omimo, A., Ntabona, A., Simmons, R. and Fajans, P., 2014. Beginning with sustainable scale up in mind: initial results from a population, health and environment project in East Africa. Reproductive health matters, 22(43), pp.84-92.

Githiomi, C. W. 2019. Impact of Spillover Effects of Integrated Pest Management on Profitability of Non-Mango Fruit Fly Infested Crops in Meru County, Kenya (Doctoral dissertation, University of Nairobi).

Google Map. 2022. Images of Google Map of Meru County. Available at: https://www.bing.com/ck/a?!&&p=872c6b4f73e99663JmltdHM9MTY2Mjg1NDQwMCZpZ3VpZD0xMjBiMThjYS1jYmYwLTYwYjgtM2JkNS0wODc2Y2FlZTYxN2QmaW5zaWQ9NTAwNw&ptn=3&hsh=3&fclid=120b18ca-cbf0-60b8-3bd5-0876caee617d&u=a1aHR0cDovL3d3dy5tYXBsYW5kaWEuY29tL2tlbnlhL2Vhc3Rlcm4vbWVydS8&ntb=1a Accessed :2/6/2022

Granstrand, O. and Holgersson, M., 2020. Innovation ecosystems: A conceptual review and a new definition. Technovation, 90, p.102098.

Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R. and Meybeck, A., 2011. Global food losses and food waste. Available at http://www.fao.org/docrep/014/mb060e/mb060e00.pdf Accessed: 21/4/2022.

Hassink, J., Grin, J. and Hulsink, W., 2013. Multifunctional Agriculture Meets Health Care: Applying the Multi-Level Transition Sciences Perspective to Care Farming in the Netherlands. Sociologic Ruralis, 53(2), pp.223-245.

Homann-Kee Tui, S., Adekunle, A., Lundy, M., Tucker, J., Birachi, E., Schut, M., Klerkx, L., Ballantyne, P., Duncan, A., Cadilhon, J. and Mundy, P., 2013. What are innovation platforms? Innovation platforms practice brief 1. Innovation platforms practice brief 1, pp.1-7.

ICRAF. 2015. Rural advisory services: what works? A synthesis on innovative approaches for benefiting and empowering farmers. World Agroforestry Centre (ICRAF): Nairobi, Kenya. Available at: worldagroforestry.org/content.

Imaita, I. G. 2013. Training as a Factor Influencing Adoption of Innovations along Mango Value Chains in Meru County, Kenya. International Journal of Marketing Studies, 5(2), p74.

Johnny, E.G., Mariara, J.K., Mulwa, R. and Ruigu, G.M., 2019. Smallholder avocado contract farming in Kenya: determinants and differentials in outcomes. African Journal of Economic Review, 7(2), pp.91-112.

Kaipia, R., Dukovska-Popovska, I. and Loikkanen, L., 2013. Creating sustainable fresh food supply chains through waste reduction. International journal of physical distribution & logistics management.

Kaminski, J. and Christiaensen, L., 2014. Post-harvest loss in sub-Saharan Africa—what do farmers say? Global Food Security, 3(3-4), pp.149-158.

Kassim, A., Workneh, T.S. and Bezuidenhout, C.N., 2013. A review on postharvest handling of avocado fruit. African Journal of Agricultural Research, 8(21), pp.2385-2402.

Kereth, G.A., Lyimo, M., Mbwana, H.A., Mongi, R.J. and Ruhembe, C.C., 2013. Assessment of post-harvest handling practices: knowledge and losses of fruits in Bagamoyo district of Tanzania. Food Science and Quality Management, 11.

Kessler, J.J., Coninx, I., Kilelu, C., van Vugt, S., Koomen, I., Bebe, B., Soma, K., Ndambi, A., Gema, J., Obwanga, B. and Rurangwa, E., 2020. Meta-analysis of 3R Kenya findings about the transformation of the aquaculture, dairy and horticulture sectors: Recommendations to support the transition from aid to inclusive aid and trade (No. WCDI-20-116). Wageningen Centre for Development Innovation.

Kimaro, E., Msogoya, T., Municipality, T. and Salaam-Tanzania, D.E., 2012, September. Postharvest losses of mangro fruit (Mangifera indica) in Morogoro Region. In Proceedings of the RUFORUM 3rd Biennial Conference, Entebbe, Uganda (pp. 24-28).

Leitgeb, F., Funes-Monzote, F., Kummer, S., & Vogl, C. 2011. Contribution of farmers' experiments and innovations to Cuba's agricultural innovation system. Renewable Agriculture and Food Systems, 26(4), 354-367. doi:10.1017/S1742170511000251

Linn JF (Ed). 2012. Scaling up in agriculture, rural development, and nutrition. Focus 19, Brief 1. Washington, DC: International Food Policy Research Institute (IFPRI). Available at: http://eudevdays.eu/sites/default/files/focus19.pdf. Accessed :2/6/2022

Lukuyu B, Place F, Franzel S, Kiptot E. 2012. Disseminating improved practices: Arevolunteer farmer trainers effective? The Journal of Agricultural Education and Extension 18(5): 525-540. Available at: http://dx.doi.org/10.1080/1389224X.2012.707066. Accessed: 2/6/2022

Magwaza, L.S. and Tesfay, S.Z., 2015. A review of destructive and non-destructive methods for determining avocado fruit maturity. Food and bioprocess technology, 8(10), pp.1995-2011.

Matui, M.S., Gonzalez, Y.S., Gema, J. and Koomen, I., 2016. From aid to sustainable trade: driving competitive horticulture sector development: a quick scan of the horticulture sector (No. 16-03/CDI-16-045). Wageningen Centre for Development Innovation.

Matzembacher, D.E., Vieira, L.M. and de Barcellos, M.D., 2021. An analysis of multi-stakeholder initiatives to reduce food loss and waste in an emerging country–Brazil. Industrial Marketing Management, 93, pp.591-604.

Migose, S.A., Bebe, B.O., De Boer, I.J.M. and Oosting, S.J., 2018. Influence of distance to urban markets on smallholder dairy farming systems in Kenya. Tropical animal health and production, 50(7), pp.1417-1426.

Misiko M, Mundy P, Ericksen P. 2013. Innovation platforms to support natural resource management. Innovation Platforms Practice Brief 11. Nairobi, Kenya: International Livestock Research Institute (ILRI). Available at: https://cgspace.cgiar.org/handle/10568/34165. Accessed :2/6/2022

MoALF. 2016. Climate risk profile for Meru. Kenya County Climate Risk Profile Series. The International Center for Tropical Agriculture and the Kenya Ministry of Agriculture, Livestock and Fisheries. Available at https://cgspace.cgiar.org/bitstream/handle/10568/80454/Meru_Climate%20Risk%20Profile.pdf. Accessed:28/5/2022

Mokria M, Gebrekirstos A, Said H, Hadgu K, Hagazi N, Dubale W, et al. 2022. Volume estimation models for avocado fruit. PLoS ONE 17(2): e0263564. Available at https://doi.org/10.1371/journal.pone.0263564 Accessed:28/5/2022

Neufeldt H, Negra C, Hancock J, Foster K, Nayak D, Singh P. 2015. Scaling up climate-smart agriculture: lessons learned from South Asia and pathways for success. ICRAF Working Paper No. 209. Nairobi, World Agroforestry Centre. D

Peter Masinde, 2022. Food Waste Reduction and Food Quality living Lab Project. Online discussion. Available:

https://hvhl.sharepoint.com/:f:/s/O365_ProjectCoEGreen/EuvvfCnKBXBBn0McFDJ1FmYB2Rpq9NBUpdVCI8XfN-og2w?e=FB6Dfz. Presented on 3/6/2022.

Posthumus, H. and Wongtschowski, M., 2014. Innovation platforms. What works in rural advisory services? p.45.

Ramírez-Gil, J.G., López, J.H. and Henao-Rojas, J.C., 2019. Causes of Hass avocado fruit rejection in preharvest, harvest, and packinghouse: economic losses and associated variables. Agronomy, 10(1), p.8.

Rampa, F. and Dekeyser, K., 2020. AgrInvest-Food Systems Project–Political economy analysis of the Kenyan food systems: Key political economy factors and promising value chains to improve food system sustainability. Food & Agriculture Organization.

Reynolds, C., Goucher, L., Quested, T., Bromley, S., Gillick, S., Wells, V.K., Evans, D., Koh, L., Kanyama, A.C., Katzeff, C. and Svenfelt, Å., 2019. Consumption-stage food waste reduction interventions–What works and how to design better interventions. Food policy, 83, pp.7-27.

Ringo, E.J., Wambalaba, F., Matayian, K., Van Boeckel, L. and Van der Land, H., 2022. Horticulture scoping study for Kenya: sustainable and responsible sourcing of fruits and vegetables from Kenya. Match Maker Associates.

Searchinger T, Hanson C, Ranganathan J et al. 2013. Creating a sustainable food future. A menu of solutions to sustainably feed more than 9 billion people by 2050. Washington, DC: World Resources Institute (WRI)

Simpson BM, Franzel S, Degrande A, Kundhlande G, Tsafack S. 2015. Farmer-to-farmer extension: issues in planning and implementation. MEAS Technical Note. University ofIllinois at Urbana-Champaign. Available: https://agrilinks.org/library/farmer-farmerextension-issues-planning-and implementation. Accessed:2/6/2022

Snel, H., Broeze, J., Kremer, F., Osena, E., Muyela, J., Erick, J., Wanjuu, E. and van Spronsen, A., 2021. A food system analysis of Kenya's mango, avocado and poultry sectors: Assessing opportunities to reduce food losses (No. WCDI-21-185). Wageningen Centre for Development Innovation.

Steenbergen, D.J., Song, A.M. and Andrew, N., 2022. A theory of scaling for community-based fisheries management. Ambio, 51(3), pp.666-677.

Toukem, N.K., Yusuf, A.A., Dubois, T., Abdel-Rahman, E.M., Adan, M.S. and Mohamed, S.A., 2020. Landscape vegetation productivity influences population dynamics of key pests in small avocado farms in Kenya. Insects, 11(7), p.424.

Tyagi, S., Sahay, S., Imran, M., Rashmi, K. and Mahesh, S.S., 2017. Pre-harvest factors influencing the postharvest quality of fruits: A review. Curr. J. Appl. Sci. Technol, 23(1), p.12.

Tyce, M., 2020. A 'private-sector success story'? Uncovering the role of politics and the state in Kenya's horticultural export sector. The Journal of Development Studies, 56(10), pp.1877-1893.

Verschoor, J., Oosterwechel, R., Koenderink, N., Pereira da Silva, F., Hetterscheid, B., 2020. Postharvest interventions, key for improvement of food systems. Exploring the impact of postharvest interventions on

increasing food availability, stability and income generation in developing economies. Available at https://doi/org/10.18174/535929 Accessed:28/3/2022

Vlaev, I., King, D., Darzi, A. and Dolan, P., 2019. Changing health behaviors using financial incentives: a review from behavioral economics. BMC public health, 19(1), pp.1-9.

Wakholi, C., Cho, B.K., Mo, C. and Kim, M.S., 2015. Current state of postharvest fruit and vegetable management in East Africa. Journal of Biosystems Engineering, 40(3), pp.238-249.

Wanjiku, E.K., Waceke, J.W., Wanjala, B.W. and Mbaka, J.N., 2020. Identification and pathogenicity of fungal pathogens associated with stem end rots of avocado fruits in Kenya. International journal of microbiology, 2020.

Wigboldus S, Klerkx L, Leeuwis C, Schut M, Muilerman S, Jochemsen H (2016). Systemic perspectives on scaling agricultural innovations. A review. In: Agronomy for Sustainable Development 36:46.

Wigboldus S, Leeuwis C. 2013. Towards responsible scaling up and out in agricultural development. Discussion Paper. Centre for Development Innovation, Wageningen University & Research Centre: the Netherlands

World Bank Group, 2013. Global financial development report 2014: Financial inclusion (Vol. 2). World Bank Publications.

WRAP (2019b) A voluntary approach to cutting food waste. WRAP Global, REFRESH.

ANNEXES

Annex 1: Interview checklist per sub-question

Sub-questions	Checklist questions
1a. What are the roles of chain actors and chain supporters in ensuring reduction of avocado losses in Meru County?	• What are the roles of the chain actors and supporters in the chain? • What are the roles of chain supporters and actors in ensuring avocado loss reduction? • What are the challenges experienced in ensuring avocado loss reduction?
1b. What is the performance of the chain in terms of stakeholders relations, policy harmonization and product flow towards scaling avocado loss reduction?	• What are your roles in harmonizing avocado policies? • Which other stakeholders do you interact with to ensure product reach the final consumer? • How would you describe your relationship with other stakeholders? • What are the missing links within the channels? • How can the performance of stakeholders relations, policy harmonization and product flow towards be improved to reduce avocado losses?,
1c. What are the roles of formal and informal knowledge institutes in avocado loss reduction?	• What are the roles of informal and formal institutions towards scaling avocado loss reduction? • How does the institutions contribute towards scaling innovation systems?
1d. What are the roles of support services towards reducing avocado loss reduction?	• What are the contributions of the support services towards avocado loss reduction? • What are the challenges encountered? • What can be improved to reduce avocado losses?
2a. What are the current technical practices for scaling avocado loss reduction?	• What are the current technical practices for scaling avocado loss reduction? • At what levels are the technical practices carried out? • To what extent have the practices been scaled? • How can chain supporters and actors influence technical scaling avocado loss reduction?
2b. What are the current methodological practices for scaling avocado loss reduction?	• What are the current methodological practices for scaling avocado loss reduction? • At what levels are the methodological practices carried out? • To what extent have the practices been scaled? • How can chain supporters and actors influence methodological scaling avocado loss reduction?
2c. What are the enabling and disenabling environments in ensuring scaling up of avocado loss reduction?	• What are strengths, weaknesses, opportunities and threats that would enable or disenable scaling of avocado loss reduction? • What are the conditions for ensuring or to ensure successful scaling of avocado loss reduction? • At which level in the chain is there potential for scaling avocado loss reduction?

Annex 2: list of stakeholders interviewed

Institutions	Key informants Name	Contact Details
National Agricultural and Rural Inclusive Growth Project	Mr. Ng'ang'a	0738376888
Meru County Government	Mr. .Munene	0722915962
Meru university of Science and Technology	Samuel Chege	dr.amoschege@gmail.co
Kenya Plant Health Inspectorate Service	Mr. Kivi Augustine (Timau Office)	0721727385
Kaguru Agricultural Training Institute		kaguruatc@yahoo.com
Kenya Agriculture and Livestock Research	Rahab Magoti	
Ministry of Agriculture, Livestock and	Mary Mbirigi	0736216599
Horticulture crop Directorate	Anonymous	
Abogeta West Avocado Cooperative	Mr. Kinyua	0722841122

Input suppliers	Farmers centre	0714437870
Producers	Mr . Gitonga, FGD members Individual farmers	0721244946 Anonymous Anonymous
Middlemen	Anonymous	
Brokers	Anonymous	
Processors /Exporters	Biofarm Limited Keitt Exporters	0712388999 0721359547
Oil extractors	Keitt Exporters	0721359547
Retailers	Mama Karimi Groceries, Makutano	

Annex 3: Field work pictures

Overripe Hass and Fuerte varieties

FCM

Rust

Avocado harvesting tools