FOOD WASTE REDUCTION AND FOOD QUALITY LIVING LAB – KENYA (FORQLAB)

Chain interventions for food waste reduction in the Kenyan export chain of avocados

Practice Briefs




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This work has been implemented as part of the professorships Climate Smart Dairy Value Chains (VHL) and Integrated Food and Production Chains (InHolland) with students and staff of HAS Green Academy, InHolland University of Applied Sciences, Van Hall Larenstein University of Applied Sciences, and Meru University of Science and Technology in Kenya in cooperation with the Netherlands Food Partnership (NFP).

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Foreword

This booklet presents the practice briefs (popular papers) of master and bachelor theses and business assignments of students at three Dutch Universities of Applied Sciences: Van Hall Larenstein (VHL), InHolland and HAS Green Academy, and Meru University of Science and Technology in Kenya. All theses and business assignments were commissioned through the research project entitled "Food Waste Reduction and Food Quality Living Lab (FORQLAB)" in Kenya.

Background research project

With this project we strived to contribute to structural reduction of post-harvest food losses and food quality improvement in the Kenyan avocado and dairy value chains through the application of technical solutions and tools as well as improved coordination in those food chains.

The consortium had four types of partners: 1. Universities (2 Kenyan, 4 Dutch), 2. Private sector actors in those chains, 3. Organisations supporting those chains, and 4. Network partners. The applied research has been implemented in cooperation with all partners, whereby students at involved universities conducted most of the field studies and all other consortium partners support and interact depending on the phases.

The FORQLAB project targeted two areas in Kenya for both commodities, a relatively well-developed chain in the central highlands and a less-develop chain in Western-Kenya. The research methods were the business to business and multi-stakeholder (living lab) approaches to increase the potential for uptake of successful interventions in the chain.

The project consisted of four phases: 1. Inventory and inception, 2. Applied research, 3. Spreading research outputs through living lab networks, 4. Translation of project output in curricula and trainings. The outcomes were: two knowledge exchange platforms (Living Labs) supported with some advice for sustainable food loss reduction, a research agenda, proposals for ICT and other tech solutions and an implementation strategy; communication and teaching materials for universities and TVETs; and knowledge transfer and uptake.

The project ran from 1 June 2022 till 31 November 2024. Master students have conducted food loss audits, in which they evaluated the current state-of-the-art of food losses in both the dairy and avocado food systems. In the following phase, research agendas were set in multi-stakeholder forums around each participating cooperative followed by in-depth Bachelor and Master research and business assignments from all participating universities.

All research contributions in report and video pitch, you can find on the NFP connect platform: https://www.nfpconnects.com/communities/forqlab-living-lab-on-food-losses-in-kenya

FORQLAB participated in the WUR/KOM project in cooperation with NFP on food-loss solutions: https://subsites.wur.nl/en/food-loss-solutions.htm

The project team and researchers aimed to contribute to the food loss reduction and food quality in the dairy and avocado sector in Kenya. We hope you will appreciate the efforts reported in this avocado booklet of the project.

Marco Verschuur (project leader FORQLAB), Peter Bouma (researcher avocado value chain), Woody Mayers (prof. Integrated Food Production Chains) & Robert Baars (prof. Climate Smart Dairy Value Chains)

May 2025

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Avocado chain advisory report – Management summary

Woody Maijers, Wendy Martin, Caicheng Huang, Peter Bouma

Summary Advisory report
FORQLAB Project 2025-9

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

The Food Waste Reduction and Food Quality Living Lab (FORQLAB) is a consortium led by four Dutch universities of applied sciences: Van Hall Larenstein, HAS Green Academy, InHolland, and Aeres, in collaboration with two Kenyan universities, Egerton University and Meru University. FORQLAB follows a living lab approach where students and teachers collaborate with business partners to find and test solutions.

Around thirty projects focused on the avocado supply chain in Kenya and were facilitated for students through the living lab platform. The common objective of these projects was to develop new knowledge and action perspectives for local smallholder farmers and cooperatives, thereby contributing to food security in Kenya and strengthening the export position. This was achieved by conducting practice-oriented research aimed at the structural reduction of food waste and food losses in the avocado export chain through efficient business-to-business partnerships and technology.

The project consisted of four phases: 1) Inventory and inception, 2) Applied research, 3) Communication of research outputs through living lab network meetings, and 4) Translation of project outputs into curricula, trainings, and routine business operations in the chain. This report was written to summarize the results of the 23 applied research projects and provide advice based on projects carried out in phase 2. The focus areas were the Meru and Nandi regions. For the report, the research questions were organized into three broader themes:

- Understanding the avocado value (export) chain
- Determining the technical interventions required to encourage safe products and reduce food losses
- Identifying the governance interventions needed to ensure safe products and reduce food losses of avocados in both local and export-oriented food systems.

From a simpler perspective the avocado supply chain is dived into 2 distinct types of supply chains: large export commercial orientated chain and the more dominant informal sector supplied by small scale growers. The focus was the latter type. The results show that the small holder avocado chain in Kenya is a complex network with formal and informal relations. A sector with different production and value flows like fresh avocados and oil. To some extent both chain types share similar challenges in reducing waste and in accessing new/ international markets. In regions like Meru and Nandi, even though most growers sell through the cooperatives, the fragmented nature of the production streams make it complex to add and monitor value within the chain. Many options for improvement in the chain were identified and implemented by the cooperatives. Additional options to create value out of wasted avocados are presented. For the export market changes for frozen products were investigated.

A major future challenge is traceability. Traceability is an added value essential to access more profitable export markets. But difficult to achieve. It requires ICT readiness, social innovation along the value chain to establish adoption of track and trace systems. Although in various studies development and progress were identified in implementing infrastructure for ICT on a regional basis, challenges were identified in the take up in the small-scale sector, mostly due to cultural and competitive concerns. ICT platforms can facilitate more efficient and effective collaboration between wholesalers and retailers where it was identified large volumes of wastage occurs due inaccurate forecast in supply and demand. Improved coordination and information flows between these actors in the value chain, would allow for improved usage of storage facilities and quality prediction.

While government agencies provide essential support, their resources are limited, leaving many growers without access to necessary information and services. While cooperatives can also play a role in supporting technical support, it is government agencies which have ownership of the certification schemes for certified plant material and enforce the regulations for export quality and administrative processes. Acquisition of Knowledge in the small-scale sector was identified as key driver in the chain development and in reduction of waste. It was nice to notice that the leadership of the involved cooperative were very engaged and learned a lot and took the lead to introduce the results from the projects in the value chain.

The specific recommendations in the advice report were drawn from the results of the students' projects and from the trial shipments which were organised by the cooperatives in Kenya and the European partners. These recommendations fell into four categories

- Advice related to the production and supply chain
- Application of ICT
- Specifications in storage and transport
- New product / market opportunities for fresh avocado and rejected avocados.

Establishing the right interventions and measuring their impact are critical for successful reduction of food loss waste. The Web based tools developed by WUR are also recommended to help future decisions in the Kenyan avocado supply chain. The tools allow identification of hotspots and can help quantify the results of each action, which are critical when applying limited resources.

Handling perspectives for cooperatives and their chain partners

To structurally reduce food losses in the last month from field to port to below 10%, we propose a *joint handling agenda* with five lines of action and a clear division of roles:

1. Organised and safe harvesting
    - Cooperatives set up permanent, trained picking teams (train-the-trainer model) and work with digital harvest forecasting and planning, based on dry matter measurement and visual quality checks.
    - Farmers deliver fruit exclusively in ventilated, reusable plastic crates.
    - Exporters can (pre)finance harvesting tools and link quality bonuses to correct picking and crate use.
2. Rapid collection and pre-cooling (6–7°C/90–95% RH within 6 hours)
    - Each cooperative sets up at least one refrigerated collection and sorting hub connected to a crate pool; cooling capacity is owned, rented or leased through public-private partnerships.
    - At the hub, a QC team records the following for each batch: grower ID, date, size sorting, dry matter %, and visual damage. This data feeds into a traceability system and the quality feedback to the farmer, exporter and importer.
    - Double sorting/grading stream, the hub enables direct separation into Class I/Bio, Grade 2, and residual streams.
3. Conditioned transport & containerisation
    - Logistics service providers guarantee refrigerated road transport (≤ 8 °C) and controlled temperature and atmosphere containers (reefers) at sea.
    - Wireless data loggers in every shipment, shared in real time with the grower, cooperative, and importer; deviations lead to immediate corrective action.
4. Quality and loss monitoring
    - All chain partners use a single, digitally shared FLW dashboard (kg class I, kg rejected, causes) and review it monthly.
    - Targets for 2026: < 12% total post-harvest losses, ≥ 85% class I on arrival, < 2% claims based on temperature deviations.
    - Development of a continuous quality improvement program by the collaboration (union) of avocado farmers.
5. New product and market opportunities and value addition rejected avocados
    - Develop a product line and market segment for biological certified avocado's (minor defects are allowed). The cooperatives find it difficult to compete based on a cost leadership strategy.
    - Develop with partners individual Quick Freezing (ICF) avocado cubes. This makes the cooperatives less vulnerable for seasonable demand and improves the cashflow planning.
    - Develop avocado oil out of the second-grade avocados. International cosmetics and health brands are asking for "upcycled" oil; there's also local demand for cooking and baking oil.
    - Use rejected avocados for development of animal feed & compost. Insects, such as black soldier flies (BSF), can convert waste streams into high-quality protein for poultry, pigs, and fish. Remaining streams can be converted into high-quality compost for orchards.
6. Maintaining the Living lab principals and meetings

- The cooperatives organise at minimum two living lab meetings with the relevant stakeholders involved (local) government, education (MUST university, Meru, Kenya), value chain partners.
- The universities are advised to develop learning material to be used in their curricula but also to develop capacity of farmers through train the trainer programs.

Consistent implementation of these six lines creates a win-win situation: higher payout prices for members, fewer claims for exporters and importers, and a demonstrable reduction in the CO_2 and food loss footprint in the chain.

ICT readiness assessment for an integrated chain-wide traceability system: A case study of the avocado value chain in Nandi County, Kenya

Cynthia Onyangore, Geert Houwers, Marco Verschuur, Robert Baars

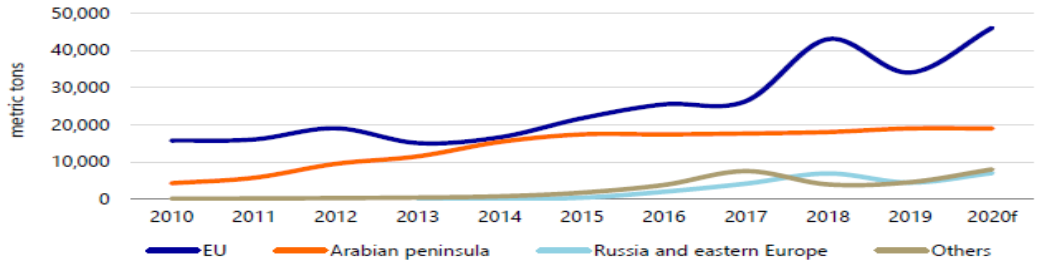
Practice Brief
FORQLAB Project 2022-04

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

van hall larenstein
university of applied sciences

According to Snel et al. (2021), Kenya is ranked among the top 10 exporters of avocados in the world. Demand for Kenyan avocado in both the domestic markets and international market is increasing especially for Hass variety. The largest exports of avocados are to the EU. Other export destinations include the Middle East, UK, and other countries in Eastern Europe (Figure 1).

Figure 1:Kenya's avocado exports by destination



Source: Rabobank Research (2020)

Rabobank (2020) noted that with Kenya's avocado sector expected to grow at around 1,500 hectares per year, there is the need for transformation of the avocado sector towards higher quality fruit and more efficient logistics in the mid to long term to be able to compete in international markets. And with increase in production, there is the need to open up into new markets. This then, calls for increased joint efforts to improve quality, improve reputation and gain access to wider markets.

Traceability in Agriculture Chains

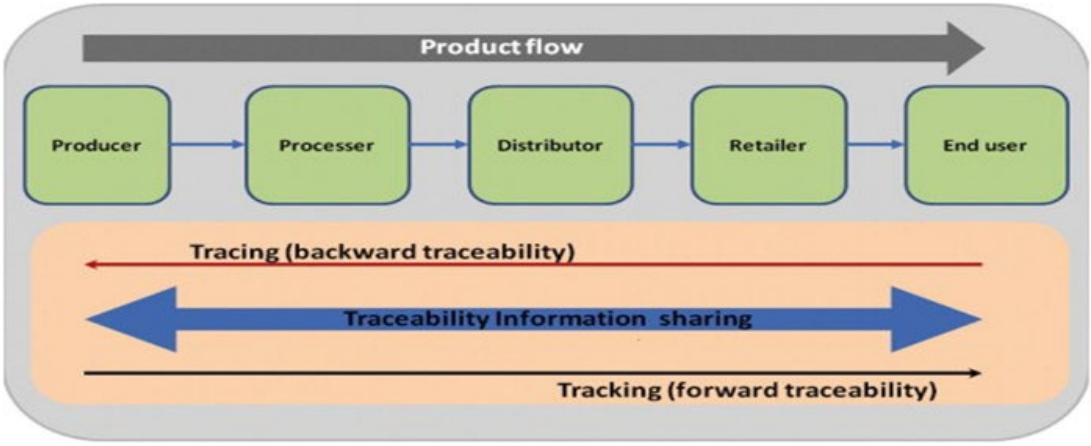
Food safety is increasingly becoming a big concern for consumers for fresh food in local and domestic markets. Chemeltorit et al. (2018) noted that traceability has evolved from merely guaranteeing the movement of food through the value chain, to ensuring food safety for consumers. They further noted that global standards in food safety have seen stakeholders in food chains become more cognizant of the need to have tracing mechanisms in the food value chains.

Dengerink and Van Rijn (2018) noted that poor value chain governance in terms of market institutions, information flow and chain relations among the stakeholders in the avocado value chain hinder the effective growth of the stringent requirements in place for export markets. This is due to the inadequate product standards, traceability and certifications required for these export markets.

According to Gichure et al. (2016), the success of implementing traceability is facilitated by proper documentation (record keeping), compliance to quality management standards, capacity building on food quality & safety and traceability management, as well as proper monitoring of the quality management system. To implement a successful traceability system, there is the need to understand the complexity in the good organisation and other requirements as observed above.

A chain-wide traceability system in the avocado value chain will allow for end-to-end transparency in the avocado value chain in Nandi County. From the demand side, it allows for end-buyers the capacity for backward traceability, to the source. From the supply side, it will allow for improved market linkages due to conformity to required standards. Ultimately an integrated chain-wide ICT enabled traceability system allows for transparency, reduction in food loss and wastage and better domestic and export market linkages for smallholder producers of avocados (Figure 2).

Figure 2: Traceability information flow in food supply chain



Source: Bosona and Gebresenbet (2013)

Study objective

The objective of this study was to assess the readiness in adopting integrated chain-wide ICT based traceability solutions in the local and export oriented avocado value chain(s) in Nandi County, Kenya. The overarching goal was to assess the readiness of stakeholders in the avocado value chain in Nandi County to adopt integrated chain-wide ICT enabled solutions, from farm to fork in providing traceability, transparency, increased food safety and linkages to local and domestic markets. The study also aimed at making an inventory of ICT solutions that can be implemented, chain-wide to allow for traceability solutions.

The study area was carried out in all subcounties of Nandi County, located in the North Rift region of Kenya. These included: Tinderet, Nandi Hills, Aldai, Mosop, Chesumei and Emgwen. A social

constructionist framework was used in carrying out this research to allow the interviewees to be fully engaged in the knowledge construction process (Laws et al, 2013).

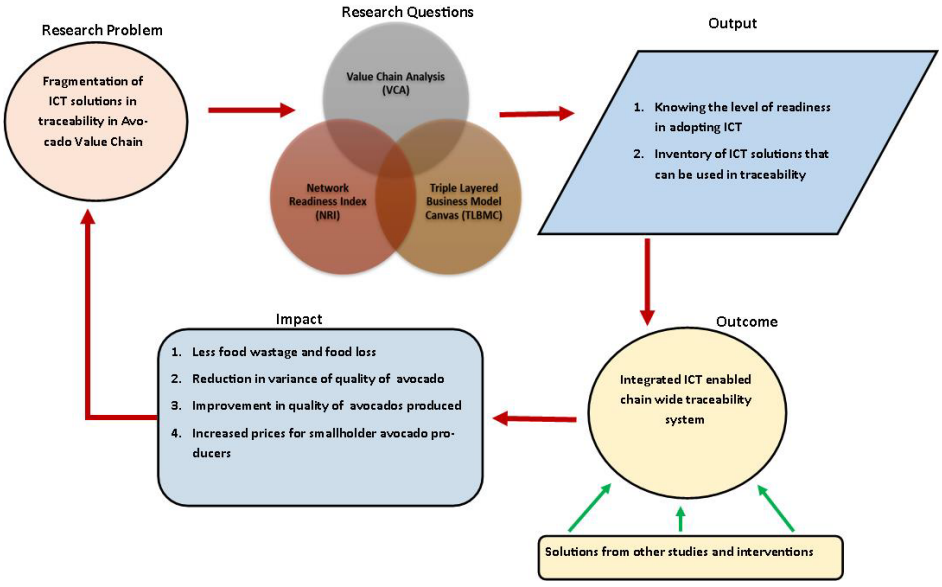
Qualitative research methods were used for this study to aid in finding out in-depth information about the readiness for adopting integrated ICT-based traceability solutions in the avocado chain in Nandi County. Desk reviews, semi-structured interviews, and an in-depth case study analysis of the successful avocado value chain in Mexico were used to collect data. The case study explored the Association of Avocado Exporting Producers and Packers of Mexico (APEAM). Mexico is the world's largest exporter of avocado and APEAM represents 74 packing houses, 30,000 growers in 42,000 orchards. (Avocado Institute, 2022). This tracked an avocado journey from production in Michoacan in Mexico to Philadelphia in the USA. This was by viewing and analysing a documentary capturing this process.

Purposive sampling was used to identify the sample of experts and stakeholders to be interviewed. Snowballing was used to identify the experts and stakeholders to be included in the sample. A total of 23 interviewees were included. These included stakeholders in Kenya and business partners in the FORQLAB project in the Netherlands and allowed for a full spectrum on insights from farm to fork. Interview sessions were conducted face to face, and some were carried out by video call (MS TEAM or Zoom) to accommodate interviewees schedules. Some interviews were video recorded while some were not as interviewees declined any form of recording. For two of the ICT-experts, multiple interviews were conducted to follow up on technical terminologies used during interviews. This allowed for a more in-depth understanding of the information provided. One of the ICT-experts preferred having the questions mailed to her for responses.

Conceptual Framework

The study was modelled on a conceptual framework combining the Network Readiness Index (NRI), (Porlutans Institute, 2021) Value Chain Analysis (VCA) (Lundy et al., 2014) and The Triple Layered Business Model Canvas (TLBMC) (Joyce and Paquin, 2016) (Figure 3). The outcome of the study was the contribution towards integrated ICT enabled chain wide traceability in the avocado value chain.

Figure 3: Conceptual Framework for study



Source: Authors compilation

Main findings

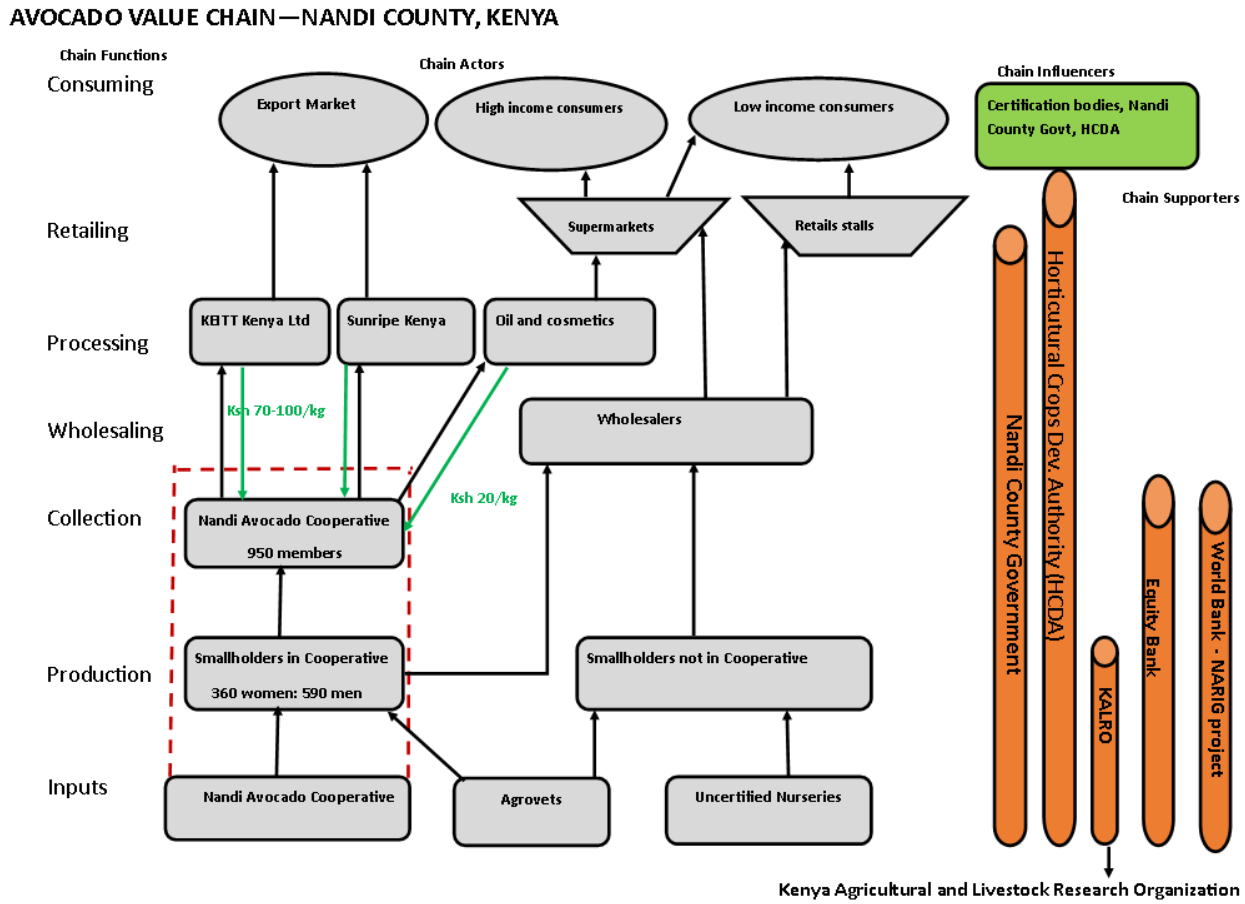
The study determined that value chain stakeholders played different yet integral roles in ensuring the development of an integrated ICT-enabled chain wide traceability system. This is through their various functions, capabilities, and linkages to other stakeholders (Table 1). Indirect stakeholders and business partners in the FORQLAB project (Avodemia, Fairtrasa and Airflo) were also included.

Table 1: Stakeholders and their role in an integrated traceability system

Stakeholder	**Role and interlinkages in the VC**
Chain Actors	Production, collection, sorting and grading, marketing and trading of the avocado among the different actors along the value chain
Chain Supporters	Business support and funding to chain actors to ensure improved production and marketing of avocados
Chain Influencers	Regulate the quality of agricultural inputs and produce and licencing of buyers.
Indirect Stakeholders and business partners in the FORQLAB project	**To knowledge share on technical expertise pertaining to the avocado value chain**
1. Avodemia Ltd	To highlight traceability steps in production and export of avocados
2. Fairtrasa Holland BV	Highlighting the traceability steps and organizing smallholder producers of avocados in Peru and Chile
3. Airflo Logistics	Highlighting the traceability steps and logistics management of fresh produce chains

The various stakeholders in the Nandi Avocado value chain are represented in the value chain map (Figure 4).

Figure 4: Avocado Value Chain - Nandi County



Source: Authors compilation

The PESTEC analysis then analysed the external environment of the avocado value chain in Nandi County in relation to assessing ICT readiness (Table 2). This analysis allowed for the identification of gaps, leverage point and trade-offs in the ICT readiness of the avocado value chain in Nandi County. There existed a big gap in the production of avocadoes in Nandi County that meet quality requirements for the export market. The quality requirements were not well understood by farmers leading to their avocados being rejected. There was also no traceability mechanisms for avocados produced; traceability ended after collection of the avocados from the farms. There were however local and emerging technologies that can be leveraged to ensure the quality and traceability of avocados is addressed. As more farmers embrace the shift to avocado cultivation, there is more land being cleared to establish farms and this could lead to a decline in the production of other cash crops in the region e.g., tea and maize.

Table 2: PESTEC Analysis of Nandi Avocado Value Cain

P	POLITICAL	• Nandi County coordinates the agriculture policy with avocado being a priority crop for diversification
E	ECONOMIC	• Funding from the Nandi County Government • Partnerships with different organizations e.g. World Bank, Equity Bank and Safaricom • Rising demand for quality avocados in the domestic and export markets • Opportunity to get certifications through the cooperative
S	SOCIAL	
T	TECHNOLOGICAL	• Increasing use of MPESA for payment services • Use of smartphones and social media for communication • Improved internet connectivity in the County. • Partnership with Safaricom
E	ENVIRONMENTAL	• Diversification into avocado farming in the County • Suitable Climate to grow avocados • Avocados intercropped with other crops
C	CULTURAL	• Quality avocados are being embraced for their nutritional qualities

Source: Authors compilation

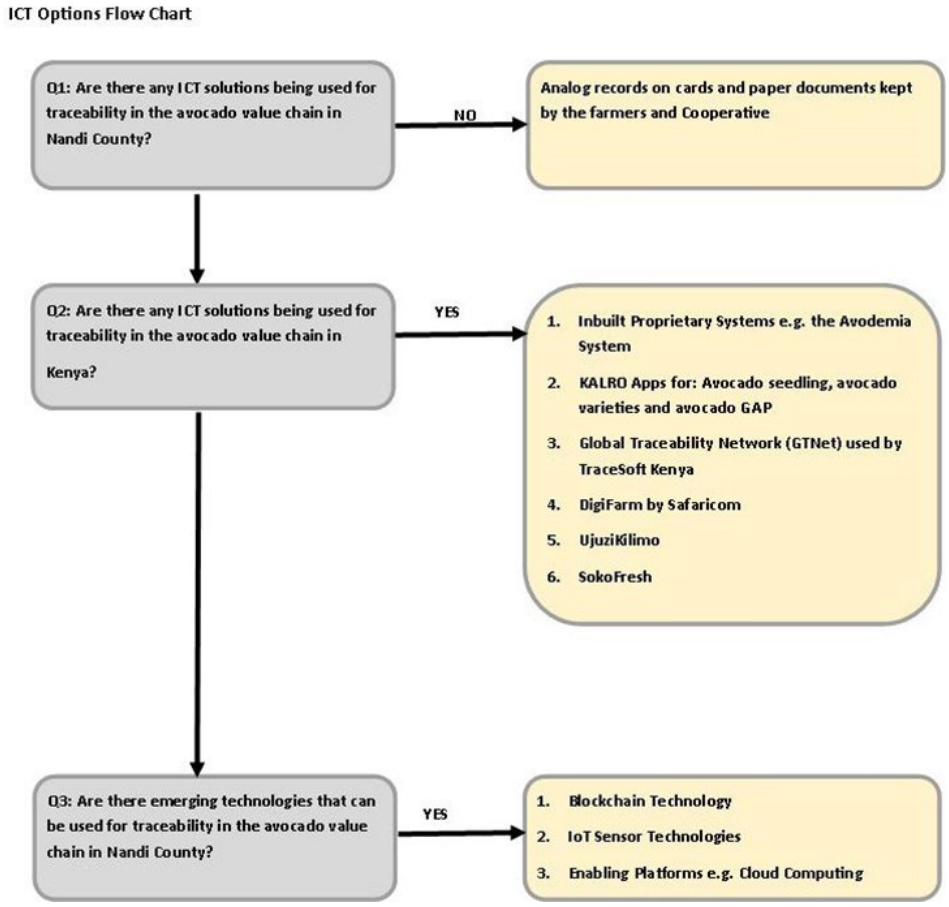
From interviews with avocado value chain actors in Nandi County i.e. farmers, cooperative officials, County Government representative and traders, there were no ICT tools being used in the traceability process. ICT tools like social media and mobile payments were being used for administrative purposes, but not for traceability. Traceability for the avocado farmers ended when their harvested avocados were collected by the exporters, Keitt Kenya Ltd and Sunripe Kenya. Records were kept in analogue form on cards and paper files at the cooperative office (Figure 5). These records only identified the farmer, variety of avocado supplied and the route name.

Figure 5: Analog farmer records

Source: Nandi Avocado Cooperative Society

Interviews conducted with ICT experts in Kenya on traceability options in Kenya, noted that there are ICT-enabled traceability options currently being used in Kenya, such as Avodemia system, KALRO apps, GTNet, DigiFarm, UjuziKilimo, SokoFresh. In addition, there are emerging technologies, such as Blockchain, IoT Sensor, Cloud Computing Platforms, that can be used to implement an integrated chain-wide traceability system in the avocado value chain in Nandi County (Figure 6).

Figure 6: ICT Options Flow Chart



Source: Authors compilation

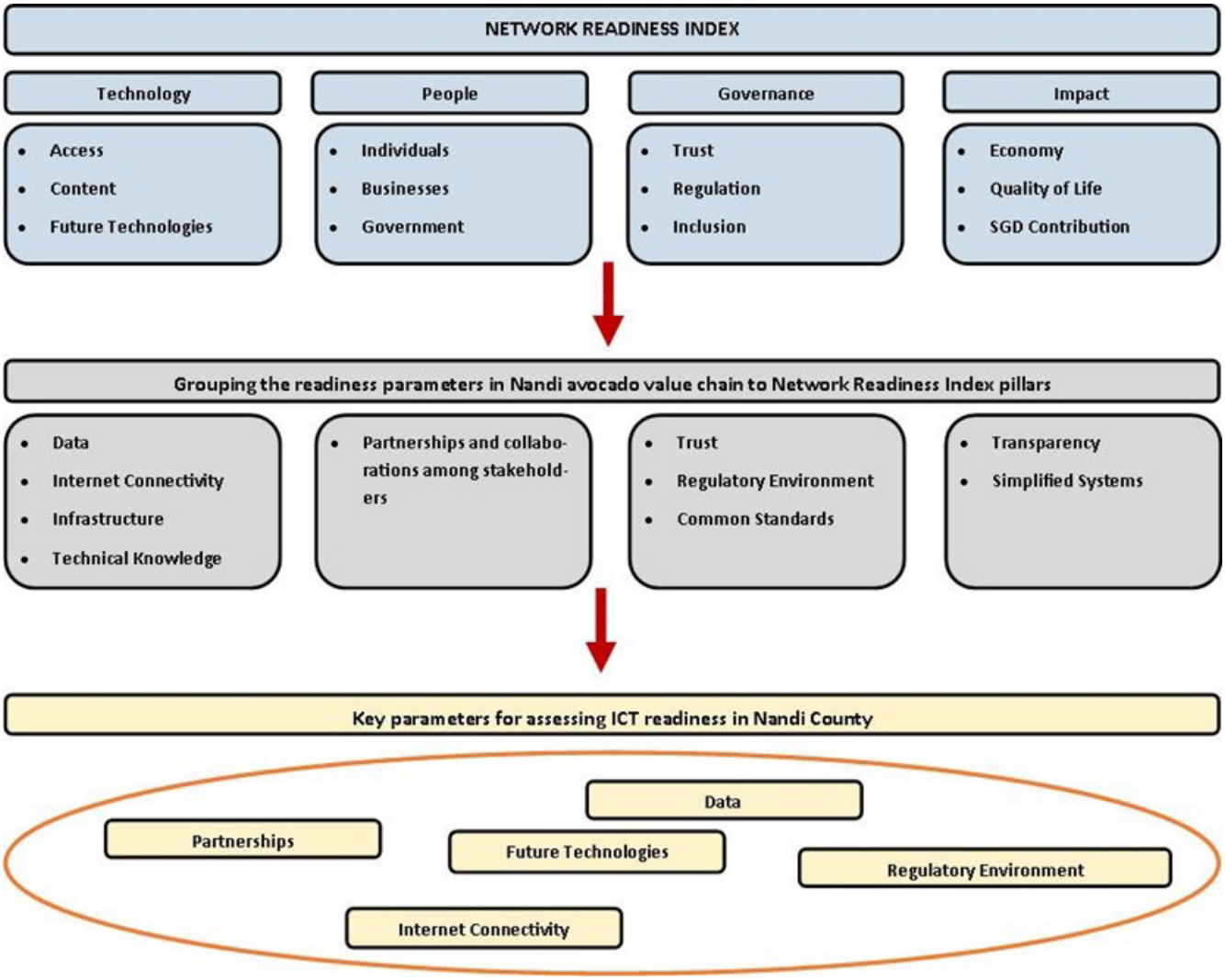
What emerged from the ICT solutions available was that presently, we have fragmented solutions in the value chain e.g. KALRO Apps provide solutions only at input supply and production levels. SokoFresh provides first mile cold storage solutions i.e. from the farm to the local markets. Companies develop proprietary systems to trace and track only the information they require at their operating level. However, according to interviews with ICT experts, emerging technologies have the capability to develop an integrated chainwide traceability system.

Five important parameters were identified as being key to assessing ICT readiness in the avocado value chain in Nandi County (Figure 7). These were:

- Partnerships and collaboration by different stakeholders
- Sufficient and relevant data at all levels in the value chain
- Reliable internet connectivity

- Enabling regulatory environment
- Leveraging on emerging technologies

Figure 7: ICT readiness assessment for Nandi avocado value chain



Source: Authors compilation

Conclusion

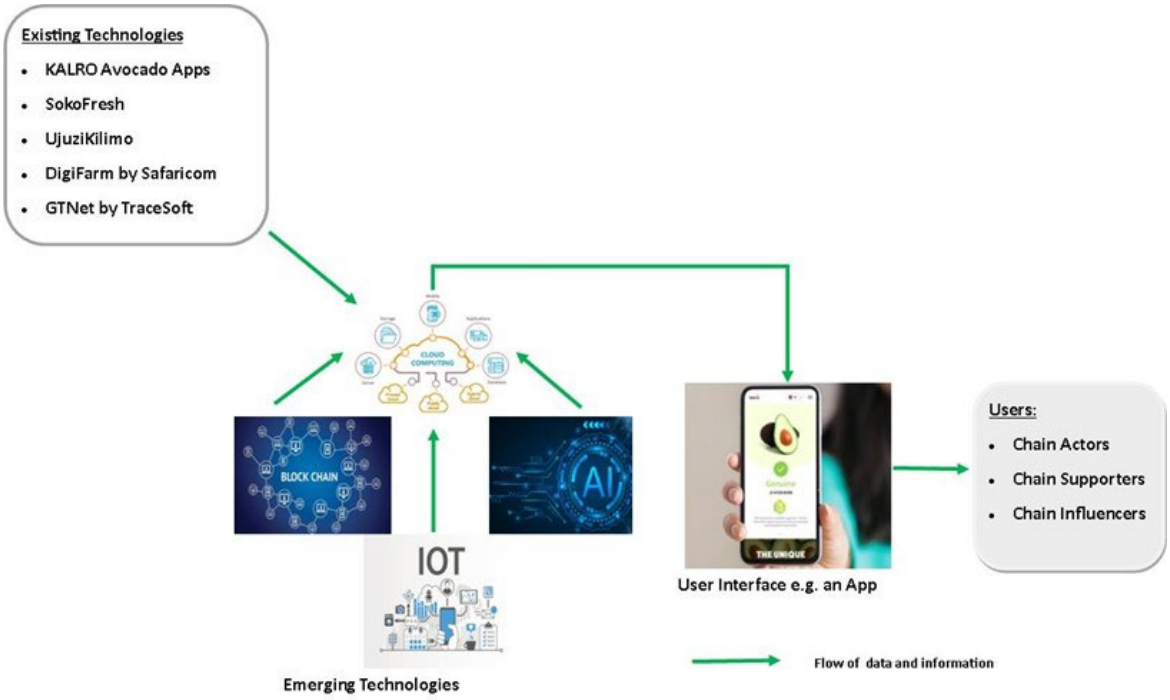
Based on the study, it emerged that an integrated ICT-enabled traceability system has the following attributes:

- Information transparency and symmetry, meaning all stakeholders in the chain have access to the same information.
- There is trust among the various stakeholders in the chain and in the information shared among them.

- Transactions must all meet a validity threshold where all stakeholders are able to verify data presented and shared.
- There is harmonization in the different levels, processes, functions, and stakeholders in the chain.
- A simple interface that allows for different users to access information from the system.

These are functions addressed by the emerging technologies like Blockchain which offers immutable, decentralized, and distributed ledgers, meaning information cannot be altered once in the system, is not owned by any one stakeholder, and can be assessed by all stakeholders. It can therefore be concluded that a hybrid combination of existing and emerging technologies will allow for the development an integrated ICT-enabled traceability system in the Nandi avocado chain (Figure 8).

Figure 8: Hybrid ICT-enabled Traceability System



Source: Authors compilation

Recommendations

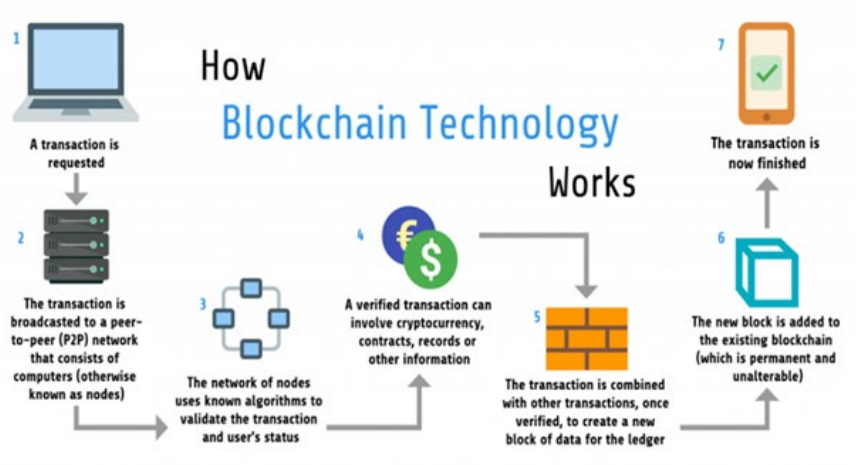
Two pronged recommendations were put forward to Nandi Avocado Cooperative Society and the FORQLAB project as areas of intervention in ICT readiness adoption for an integrated chainwide traceability system.

1. **Technology Intervention**

Developing a technology solution would require a customization from the existing and emerging technologies and in a manner that includes and links all the stakeholders in the value chain. Solutions like Blockchain and IoT would effectively address the traceability aspect and ensure end-to-end

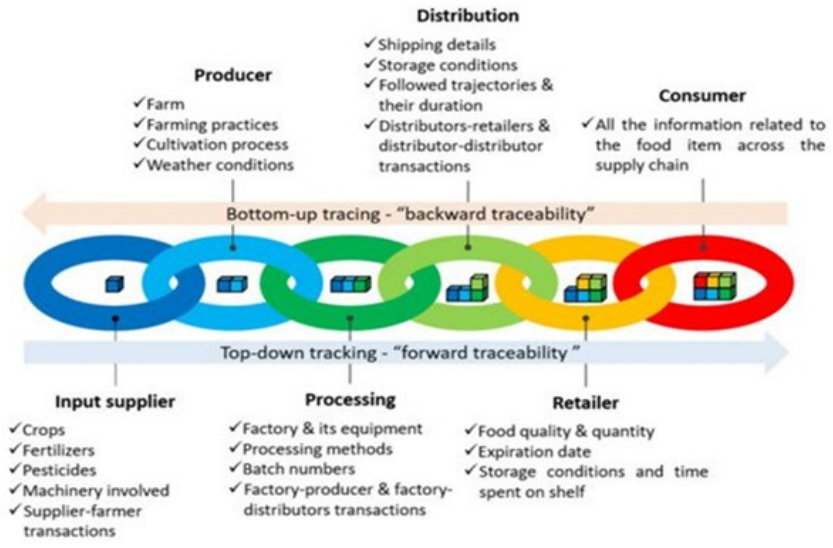
traceability in the value chain. Figure illustrates how Blockchain and IoT can be used to implement this traceability system.

How Blockchain Technology Flows



Source: https://medium.com/@ipspecialist/how-blockchain-technology-works-e6109c033034 (2022)

IoT monitoring in the fresh produce food chain



Source: Tagarakis et al (2021)

2. Value Chain Governance Intervention

Value chain governance interventions include strengthening the partnerships among the various stakeholders in the value chain. A multi-stakeholder approach to traceability ensures proper cooperation and coordination to achieving this objective. Public Private Partnerships (PPPs) will allow for standardisation of processes through certification of farmers. Traceability is based on shared standards and certification. Certification is a costly and lengthy process for individual farmers, but these costs can be significantly reduced if certification is done through the cooperative society. By leveraging on the

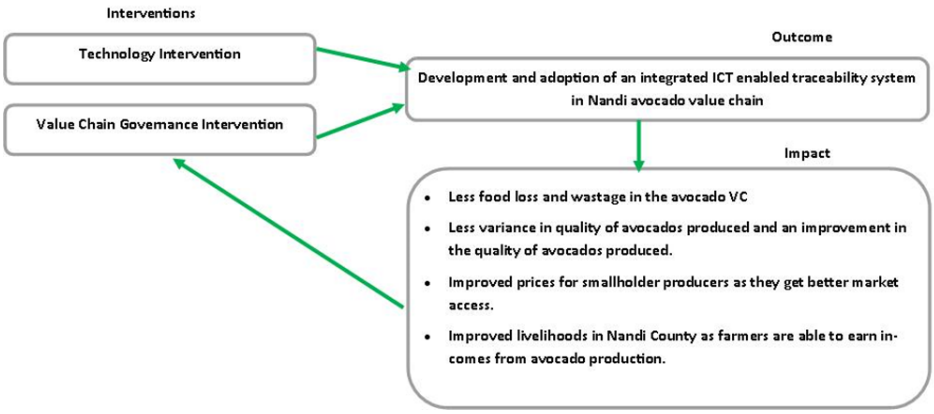
already existing partnerships in the value chain e.g. the NARIG project, the benefits accrued from stakeholders in a value chain working together will be realized.

While being cognizant of the power dynamics between the different stakeholders and the shift from an analogue to digital approach to traceability, it can also be noted that implementation of these interventions should be gradually done, and in phases and in a consultative manner to both allow for buy in and corrective measures to be done. It is a delicate balancing act, requiring the inclusion of all stakeholders in relevant processes.

Impact

The technological and value chain governance interventions when well effected, will allow for the development, adoption and implementation of an integrated ICT enabled traceability system in the Nandi Avocado value chain. Karippacheril and Srivastava (2017) noted that traceability has become an integral part of ensuring shared standards in maintaining food quality and food safety standards. Production of quality avocados, meeting shared standards in the Nandi avocado value chain, will lead to less food loss and wastage, ensure avocado farmers in Nandi County get better prices for their produce and improve their livelihoods (Figure 9).

Figure 9:Impact of ICT enabled Traceability System



Source: Authors compilation

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Analysis of Food Loss and Waste in Avocado Value Chain
A case study of Avocado Value Chain among the avocado smallholder farmers in Nandi County, Kenya

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Practice Brief
FORQLAB Project 2022-05

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

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Introduction

Avocado farming is becoming increasingly important for smallholder farmers in Nandi, Kenya, amidst a growing global demand for the fruit. However, food loss and waste (FLW) pose significant challenges along the avocado value chain, particularly affecting these farmers. In Kenya, approximately 20% of avocados were lost during harvesting due to premature picking and inadequate post-harvest management, contributing to economic strain on local farmers (Snel et al., 2021). Factors such as poor transportation, limited storage facilities, and a lack of market access exacerbate these losses, with smallholders facing higher FLW rates compared to larger exporters (Luo et al., 2021). This highlighted the need for a comprehensive understanding of FLW occurrences in Nandi to devise strategies that enhance efficiency and reduce waste in the avocado sector (Chauhan et al., 2021).

Research Methodology

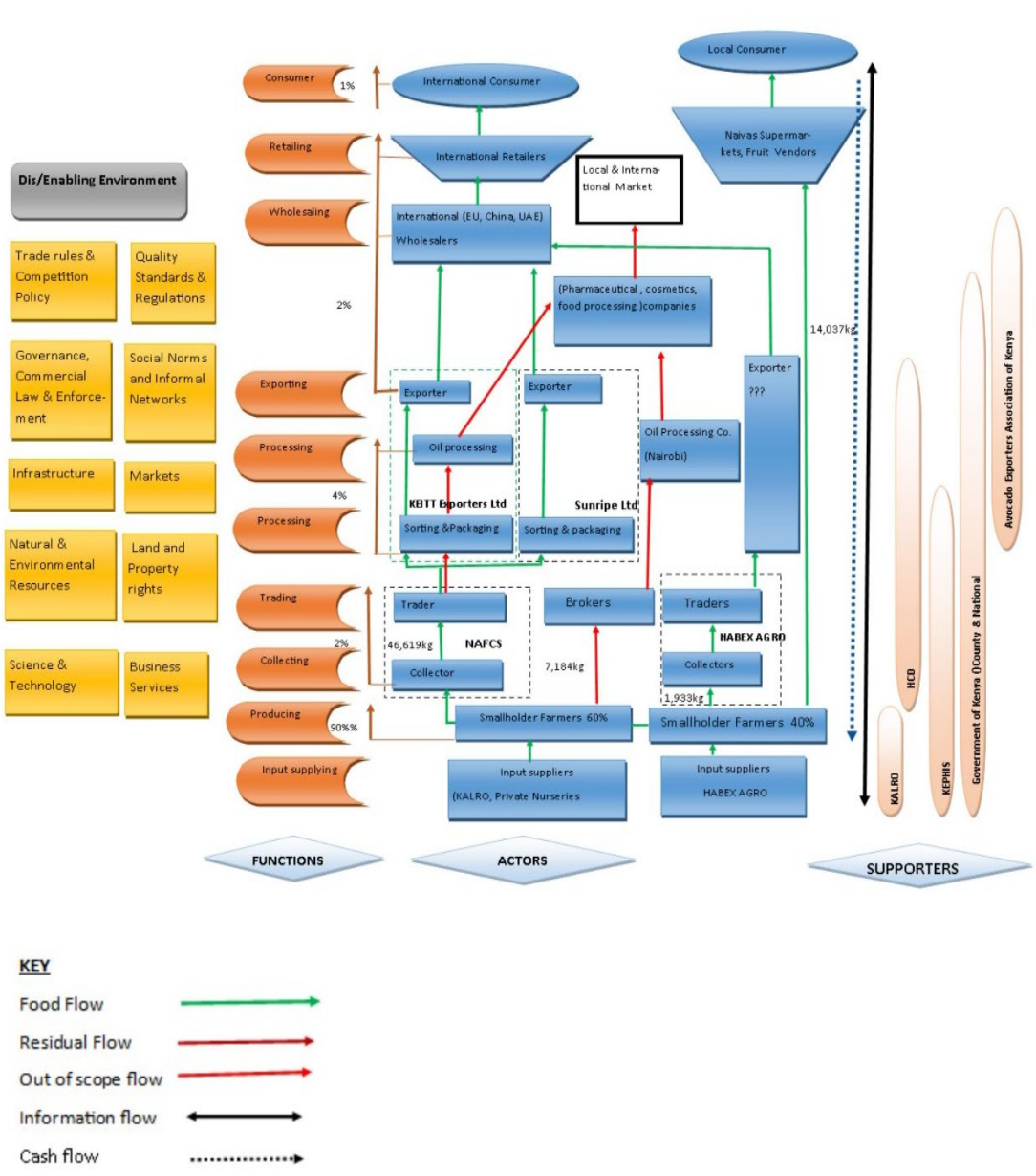
The study applied a descriptive research design to explore avocado losses and waste along the value chain in Nandi County, Kenya. Data collection was from July to August 2022, and involved a survey using a questionnaire and a case study with farmers, traders, cooperatives, and government officials. Secondary data came from government records and academic sources. Quantitative analysis was conducted using SPSS and Excel to estimate FLW, economic impact, and carbon footprint. This approach aimed to identify loss points and provide insights for value chain improvements.

The Current Avocado Value Chain

This study explored the intricate dynamics of the avocado value chain in Nandi, Kenya, focusing on the pathways through which avocados reach consumers. The flow of avocado products involved multiple channels, with the export market exhibiting a degree of clarity and transparency through established connections between buyers, traders, cooperatives, and exporting companies. In contrast, informal channels dominated by brokers and traders introduce variability in pricing, complicating the landscape for smallholder farmers. Approximately 60% of these farmers belonged to cooperatives, which served as crucial market links to exporters. However, 36% of cooperative members expressed dissatisfaction with their involvement, highlighting underlying challenges within these structures. Many farmers relied on less advanced technologies for production and harvesting, which could hinder efficiency and quality. Furthermore, the transportation of avocados posed additional challenges, as many products were

transported in open pickups or motorbikes, exposing them to direct sunlight and compromising quality. The cooperative partnered with two exporting companies, KEITT and Sunripe, while also receiving technical support from the county government to enhance their connections with export markets (Figure 1).

Figure 1: Current Avocado Value Chain in Nandi county



Smallholder Farmer Avocado Selling Channels

Farmers in Nandi sold their avocados to more than one buyer. Most farmers sold their avocados to the cooperative (48%), while some sold to both the cooperative and the retailers (3%) (Table 1).

Table 1: Selling Channels

Buyers	Percent of the Total
Cooperative	47.50%
Brokers & Traders	20%
Cooperative & Brokers	17.50%
Traders	7.50%
Brokers	5%
Cooperative & Retailers	2.50%

Estimated Food Loss and Waste

The findings presented were from interviews conducted with cooperatives and farmers in Emgwen, Nandi Hills, Kaboi, and Lessos. It is important to note that the sample collection across these regions was not evenly distributed, which limits the possibility of comparative analysis.

The overall estimated FLW in the study area was 343,412 kg per year. The production stage recorded the highest percentage of losses, accounting for approximately 90% of the total FLW. Following this, the losses were recorded as: collection and storage (2%), processing (4%), distribution (2%), and consumption (1%) (Table 2).

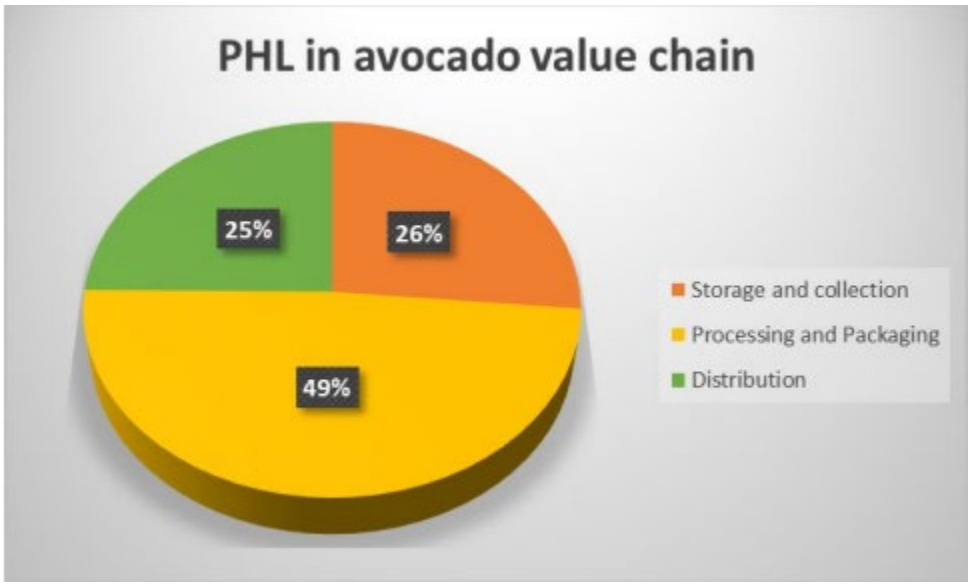
Table 2: Food Loss and Waste within the chain

Value Chain Stages	Actual FLW (kg)	Actual Percentage (%)
Food Loss		
Production	309,957	90
Collection and Storage	8,341	2
Processing and Packaging	15,365	4
Food Waste		
Distribution	7,836	2
Consumption	1,913	1
Total FLW	**343,412**	

Postharvest Losses

The post-harvest losses within the chain were approximately 45% of the total avocado harvested. Processing and packaging produced highest losses estimated at 49% of the total post-harvest losses (Figure 2).

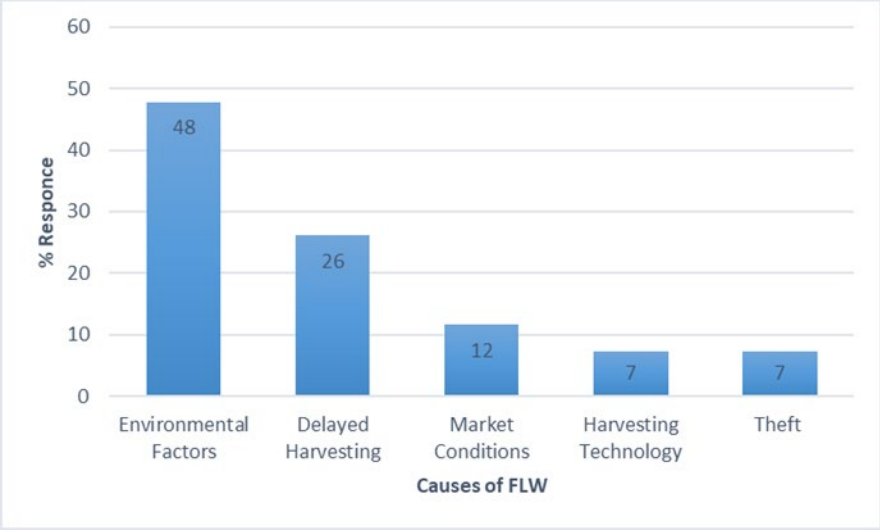
Figure 2: Overall Post-Harvest Losses



Causes of FLW in the Chain

Figure 3 illustrates causes of food losses at the production level. All respondents experienced losses. The major causes were environmental factors which represent drought, hailstones, pest and diseases, and premature dropping of the fruit (48%). Harvesting techniques and theft both had a response of 7%.

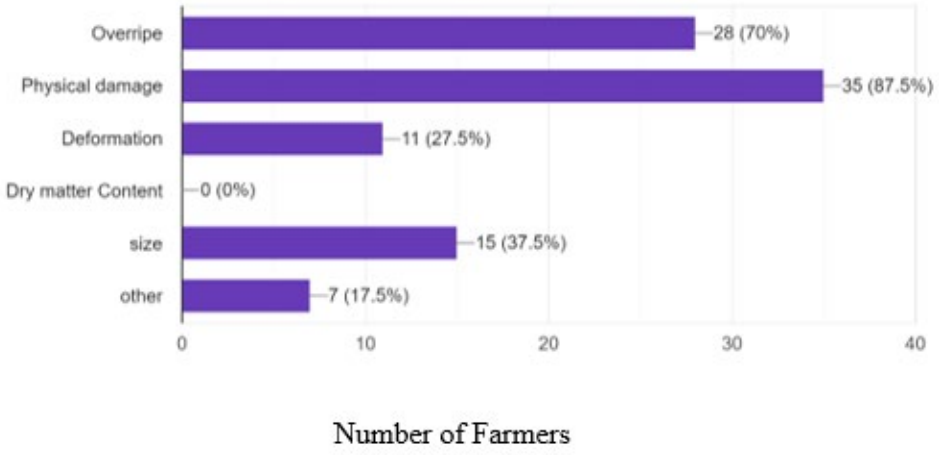
Figure 3: Causes of Food Loss and Waste at Production Level



Causes of Losses and Waste at the Collection Centre

Over 35 smallholder farmers reported that most of their produce were rejected by the cooperative due to physical damage. None of the respondents reported issues of dry matter among the major causes of rejection (Figure 4).

Figure 4: Causes at the collection centre



The identification of root causes of avocado loss at the production level revealed several critical factors. Respondents cited premature fruit dropping, delayed harvesting, pests and diseases, and drought, all linked to inadequate agricultural practices, limited market access, and poor infrastructure (Table 3). Many farmers, particularly those without irrigation systems, faced significant losses due to drought conditions.

At the post-harvest stage, factors such as bulk loading, poor transport, and inadequate packaging further contributed to food loss and waste (FLW) (Table 4). Additionally, cooperatives often lacked storage facilities, forcing farmers to use traditional storage methods that may compromise fruit quality. Addressing these root causes was essential for developing effective strategies to reduce avocado losses and improve the sustainability of the value chain.

Table 3: On-Farm Root Causes

	On-farm Loss Root Causes
1	Poor agricultural practices
2	Poor Pest and diseas management
3	Inaccessibility to market
4	Insufficient supply of protective net
5	Low Labour force
6	Poor Infrastructure
7	Lack of irrigation systems
8	Poor seedling quality

Table 4: Root Cause at Post-Harvest Level

	PHL Loss Root Causes
1	Lack/Insufficient storage facilities
2	Bulk Loading
3	Poor handling during packaging and transportation
4	Poor avocado quality
5	Poor handling during offloading

Critical Loss Points

The most substantial losses were observed at production level, particularly on farms, during harvesting, post-harvest storage, and transportation to collection centres. Mixed farming practices dominated the region, with farmers balancing avocado production alongside tea, coffee, maize, bananas, and beans. Harvesting primarily took place during the peak season (March–September), with minimal activity during the off-peak season due to limited market demand. Critical loss points identified within the value chain indicated highlight areas for improvement (Figure 5). Additionally, it demonstrated that most farmers employed suboptimal harvesting and handling practices, further contributing to post-harvest losses.

Figure 5: Flux Diagram and Critical Loss Points 9

Effects on Economic Value and Carbon Footprint

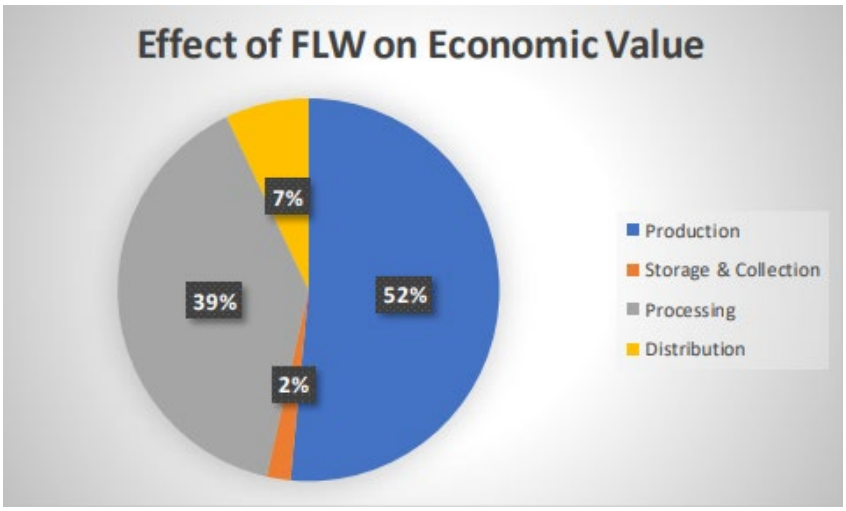
The economic impact of FLW within the avocado value chain in Nandi, is outlined in Table 5 and Figure 6. Between April and August 2022, total losses amounted to KES 33,131,886. Farmers suffered the highest losses, with 341,566 kg of avocados lost, valued at KES 16,970,146. In contrast, the cooperative recorded the smallest economic loss at KES 750,690 (2%).

Table 5 also provides an overview of the carbon emissions resulting from waste in the avocado value chain. The production stage generated the highest carbon footprint, with emissions reaching 648,975 CO2-e, accounting for 90% of total emissions due to significant waste generation. In comparison, the consumption stage recorded minimal waste, leading to a much smaller carbon footprint.

Table 5: Economic and Carbon Footprint Effects

Value Chain Stages	Total Loss (Kg)	Average Price (Ksh)	Economic value (Ksh)	Total Emission (CO2-e/kg)
Production	309,957	54.75	16,970,146	588,918
Storage & Collection	8,341	90	750,690	15,848
Processing	15,365	850	13,060,250	29,194
Distribution	7,836	300	2,350,800	14,888
Total			**33,131,886**	**648,848**

Figure 6: Percentage Economic Value of FLW



Conclusion

The avocado value chain in Nandi operated as a B-system, serving both domestic and export markets with minimal value addition along the chain. While most farmers were organised under a cooperative, poor coordination and absence of consistent markets resulted in farmers working with multiple buyers, complicating traceability, and quality management. High FLW occurred at various stages, with production level losses, accounting for 90% due to poor agricultural practices, pest and disease management issues, inadequate irrigation, and limited market access. Post-harvest losses, estimated at 45% of the total harvest, were linked to insufficient storage, poor handling during transportation, and the lack of proper packaging facilities.

FLW in Nandi's avocado value chain had significant economic and environmental implications, with losses valued at KES 33 million and a carbon footprint of 652,483 CO_2 -equivalent, primarily from poor waste management practices. Key leverage points for reducing FLW included improvements at the production, collection, and processing levels, alongside interventions in enabling environments such as business services, quality standards, technology, and regulation. This analysis provided a baseline for designing targeted FLW reduction strategies to enhance sustainability and reduce greenhouse gas emissions within the avocado value chain.

Recommendation and Interventions

To address identified issues regarding FLW in the current avocado value chain in Nandi, four interventions strategies to scale-up the value chain were identified. These interventions aimed at increasing production and quality, adding value to avocado to benefit all stakeholders, and expanding the engagements of the smallholders with markets hence reducing overall FLW. Development of these interventions were based on the identified leverage points which were divided into three sections.

Shallow leverage points

1. Enhance sustainable agricultural practices

The current production system was traditional with little application of silvicultural practices when it came to avocado trees establishment and management. Furthermore, most farmers sourced poor quality seedling since there were very few reliable nurseries with certified seedlings. Introduction of integrated pest management practices, application of silvicultural practices and utilization of certified varieties of seedlings will greatly reduce FLW to a greater extend. Additionally, part of good agricultural practices involved record keeping. Information management at farm level will enable farmers to track farming activity which will not only be helpful to the farmer but also the cooperative.

2. Establishment of low-cost temperature-controlled aggregation facility

High percentage of post-harvest losses were largely associated with lack of cold storage facility in Nandi. Most farmers were forced to use traditional methods of fruit storage which were not sufficient to maintain the quality of the avocado. Both the cooperative and the farmers experienced long wait of one or two lorries from the exporting companies in Nairobi to pick their produce. This was costly and time consuming as they must move from one collection point to another picking avocados. Establishment of small-scale cooling structure will be cost-effective for the cooperative as farmers will have one central point to bring their produce for market. Moreover, cool chain system will maintain the quality and shelf life of the avocado meant for both export and domestic market.

Intermediate leverage points interventions

3. Introduction of agro-processing facility

Value addition was one of the strategies applied to reduce food wastes. Currently, most of the rejected

avocados end up in landfills and farms, which contributed to GHG emissions. Furthermore, those being fed to animals were not fully consumed, because not all animals were fed on unprocessed avocado seeds thus contributing to waste. Currently, there is high demand for avocado oil both in local and international markets for cosmetics, consumption, and pharmaceutical purpose hence establishing a low-cost processing facility in Nandi will be a win-win situation as it will not only reduce FLW but will also create employment. Additionally, peels and seeds can be further used for production of animal concentrates which have been scientifically proven to be nutritious for domestic animals.

Deep Leverage points interventions

4. Strengthen chain coordination through collaboration

This intervention aimed at improving the robustness and stakeholders' capacity in the value chain. The main outcome was strengthening collaboration and collective action to improve and increase market access. Smallholder farmers in Nandi were constrained with various factors that prevented them from competing favourably in the avocado sector. Although the cooperative has managed to bring on board a large percentage of smallholder farmers and collaborated with few stakeholders, there was poor coordination between these stakeholders. Public Private Partnership within the chain and increased collaboration of Nandi Avocado Farmers' Cooperative Society throughout the sector will enable avocado value chain in Nandi to be competitive and resilient in both domestic and export market.

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The Potential Contribution of Value Chain Governance in the Reduction of Avocado Production Losses

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Practice Brief
FORQLAB Project 2022-06

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Introduction

Avocado production and consumption have increased significantly in recent years, with a consistent expansion into new markets worldwide (Kourgialas and Doukou, 2021). Kenya is regarded as one of the economic powerhouses of Eastern Africa, with the agri-food sector accounting for 34% of the total national GDP and 65% of all export-related earnings, including avocado export earnings. More than 80% of Kenya's population is directly dependent on agriculture for food and income (Snel et al., 2021; IRERI et al., 2021). Local, Hass and Fuerte are avocado varieties grown in Kenya. Hass is the most preferred variety in the international market, due to its long shelf life and less vulnerability to physical damage and susceptibility to pests and diseases. The Hass variety fetches higher prices on average (KES 2.55) than the Fuerte variety (KES 1.55) (Mwambi et al., 2016).

Most farming activities in Kenya are on a small scale, and their problems are multifaceted, including sub-divisions and small farm sizes, resulting in diseconomies of scale and low productivity (IRERI et al., 2021), which is the same situation for the avocado chain. Kenya is the world's seventh-largest producer of avocados and ranks eleventh on the list of largest exporters. Since 2017 Kenya is Africa's leading avocado exporter (Avocado Society of Kenya, 2020).

According to Mwambi et al. (2016), participation in export markets has positive effects on encouraging smallholder farmers to produce high-quality avocado production which is vital in increasing incomes and meeting their customers' requirements and hence alleviating poverty, in Sub-Saharan African countries including Kenya. According to Snel et al. (2021), food losses were 35% for domestic and 15% for export avocado chains and post-harvest losses are concentrated during the first mile after harvest (20%), and an additional 10% of losses occur during transport and packaging. Major causes of loss are improper handling, pest and diseases, and product deterioration due to lack of temperature-controlled storage and pre-cooling.

Methodology

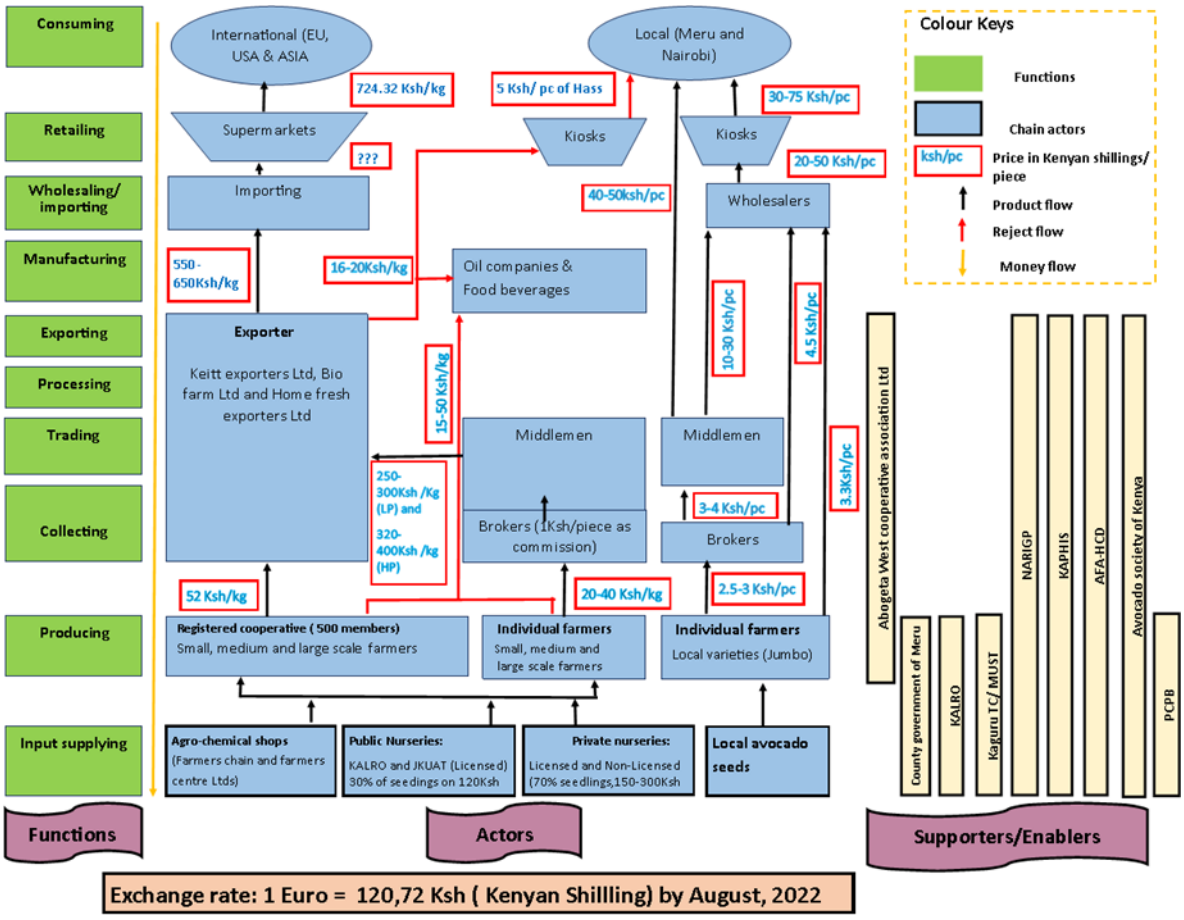
The study was conducted in a well-watered and developed avocado value chain with highlands and lowlands which is semi-arid Meru County located on Mount Kenya's northeast slopes of Kenya. Meru County is an agricultural basket that provides a high volume of export horticulture and subsistence food in Kenya. This study used a qualitative approach through data from desk and field research. A total of 20 respondents from Abogeta-West cooperative members, three middlemen, two inputs suppliers, one broker and 2 retailers were interviewed. Two different focus groups were organized, one for farmers and another for the cooperative management team. Eleven key informants (public and private) interviews were conducted. Data were triangulated and combined by field direct observation of the researcher to find the research facts. The value chain map was applied to show the chain actors and the

product flow and the 3R-method to assess value chain governance, i.e., chain robustness, reliability of institutional governance and resilience of innovation support system (Rademakers et al., 2016).

Avocado value chain map

There are two types of chains (export chain and local chain) with different varieties of avocado produce in Meru County (Figure 1). The export chain produces Hass and Fuerte varieties which have high demand in the international market, and more farmers are joining the chain. The local chain grows and produces local varieties, and the production is locally consumed. The research is more focused on the export value chain.

Figure 1: Current avocado chain map in Meru County



Source: Author

Actors, supporters, influencers and their roles

Regarding potential actors, supporters, enablers and their roles, the study revealed their spatial presence (Table 1).

Table 1: Current avocado value chain actors, supporters and enablers and their roles

No	FUNCTIONS	ROLES	Categories
Avocado value chain actors			
1	**Input dealers**: Private nursery growers that sell local seedlings; agrochemical shops that sell fertilizers, pesticides and fungicides; and private nursery growers. Public	-Supply of inputs such as seedlings, fertilizers, pesticides and fungicides	-Public and private institutions. -Agrochemical shops are owned by men, but waiters are 80% female

	institutions and individuals produce and sell avocado seedlings. Seedlings from public institutions are in 95 km far from farmers, are licensed, and accessible at 30%. Licensed seedlings are free of diseases, pure variety and have a KEPHIS certificate. None licensed seedlings are locally grown, not pure (either Hass or Fuerte), not certified and they are more accessible for approximately 70% of farmers.		
2	**Producers:** 40% of Farmers individually produce mainly Hass and some Fuerte avocado varieties for export production and 60% produce local varieties called Jumbo.	-Production and all agronomic management of orchards	Small (1-50 trees) Medium (51-150 trees) Large (151 and above) -Local varieties (individual farmers) own 1 and above trees Export
3	**Brokers/ Pickers**: individual young people in the production area. They get commission fees from middlemen which are 1 KES/piece (4 KES/kg)	-Identification of avocado farms -Link middlemen with farmers -Harvest and pre-grade -Aggregate/collection from various farmers	Men (Individuals)
4	**Middlemen**: informal traders mainly from Nairobi	-Trading -Transport to grading points -Coordinate with brokers to find the products	Men and women (individuals).
5	**Exporters**: companies which buy avocado from Meru County	-Collection -Transportation -Processing such as: -Washing -Grading -Waxing -Packaging -Labelling storing -Exporting	**Private companies:** -Exporters -Keitt exporters Ltd, Bio firm -East African fresh fruits -Key exporters Olivado (All exporting companies are owned by men, but 85% of workers are women)
6	**Manufacturing**: Companies	-Collecting -Transporting -Oil extracting	-Oil extractors e.g., soul fruit Ltd and Keitt Exporters Ltd
7	**Wholesalers**: Companies for export chains and individuals for a local chain	-Sell in bulk to retailers and consumers	Women and men (individuals)
8	**Retailers**: National supermarkets like NAIVAS and open markets in Nairobi and local in Meru County	-Sell to consumers	Women: locally called Mama Mboga (individuals in open local markets called Gakurumone, Mukutano and Kiosks)

9	**Consumers**	-Consume final avocado products -Funding of AVC	Local and international (both women and men)
Supporters and enablers			
10	Abogeta West (including five farmer groups locally called clusters) and Abothuguchi avocado growers cooperative society Ltd	-Train farmers in GAP -Identify potential market -Negotiate prices with exporters and sign farming contracts	Farmers (mainly men, very few women and no youth)
11	Meru county government	-Advocate and promote avocado production -Offer extension services e.g., training -Develop county policies -Partners with communities -Develop and maintain infrastructure	Public institution (Director is a man)
12	**KALRO**	-Train farmers on best agronomic practices -Conducting Research for finding suitable seedlings -Provision and supply of certified Hass avocado seedlings	Public institution (found a women)
13	**HCDA**	-Registration and compliance -Offer technical and advisory services -Conduct market research and product development for the horticulture sector -Monitor compliance	Government body (region office coordinator is a man)
14	**Avocado Society of Kenya**	-Offering extension services (GAP) -Linking growers with exporters who are members and exporters with international buyers -Helping Farmers and exporters to comply with market requirements on food safety and social standards -Training partners on pre-certification audits -Lobbying government for conducive policies and always playing an advocacy role in the opening of more international barriers to trade	-NGO (Growers, exporters and other value chain players) -The leader is a man but 70% of officers in the office are women.
15	**NARIGP**	-Offer advisory services -Lobby for funding such as Abogeta-West packhouse -Partner with other institutions for the development of AVC	Government project (50% are women)

16	**Kaguru VTC / Meru University (Innovation and Entrepreneurship Hub)**	-Provide extension services to farmers through farmer field schools and e -extension -Hass seedlings production and distribution services	Public institutions and around 75% are men
17	**KEPHIS**	-Ensure internal and external market compliance -Conduct inspections -Offer phytosanitary and safety certificates -Provision of extension services	Government regulatory and certification body and 60% of workers are women, but the region office coordinator is a man
18	**PCPB**	-Regulation of export and import of chemical products -Advising farmers about chemicals internationally required in avocado production	Men are more employed

Availability and accessibility of avocados transport and storage services

A big part of avocado production is packed and transported in sacks by middlemen and in crates for the formal market by exporters (Table 2). Middlemen or export companies manage avocado production transport from farmgate to warehouses. Temperature and humidity are not controlled during production collection and transport. Suitable (cooled) avocado transport services are not accessible and available in Meru County.

Table 2: Avocado transport services

Services	Service providers	Service owners
Avocado transport from the farm to local roads	Pickers (brokers) by head	Middlemen or exporters
Transport from local roads to Nairobi Packhouse	Hired small cars (locally called pro-box) or pick-ups	Middlemen
Transport from local roads to tarmacked roads	Hired or owned pickups	Exporters
Transport from tarmacked roads to Nairobi packhouse	Hired or owned normal truck or rarely humidity and temperature controlled	Exporters

Disposal of avocado losses and waste

In the avocado export chain, losses of avocados mean fruits that do not meet export requirements, while in the local chain, losses mean fruit that cannot be sold to the local markets.

There are different destinations for avocado losses: the waste from avocado production is either sold to oil extractor companies at an exceptionally low price (20-25 KES/kg) or remains in orchards as organic matter and covers the soil. In the export chain or the market pits of open markets (Mukomone or Mukutano), it is mixed with other market waste for compost in local chains (Table 3). Some visited farmers used avocado waste to feed their animals like pigs and chickens. Farmers need to put waste in pits for quick decomposition which helps in organic manure preparation and avoids spreading diseases and pests among avocado orchards.

Table 3: Losses in the avocado value chain and their destination

Function level	Estimated percentage of losses	Losses destination
Export chain		
Producer (farmgate)	23-25%	Oil extraction or animal feeding or home consumption
Packhouse	7-8%	Oil extraction or local retailers
Local chain		
Producer	9-14%	Home consumption or animal feeding
Middlemen	34-36%	Compost pits

Avocado value chain governance to reduce avocado losses

Robustness of avocado value chain

The research revealed that the avocado value chain governance in Meru County is still in the developing stage and the value chain has full actors and enough supporters which is a good factor for the chain to achieve robustness. However, the chain stakeholders are not in an active platform for further development of the chain. Regarding avocado flow, the research found that there are two avocado chains: 42% export and 58% local chains and Meru County is the Kenyan horticulture Hub. Only 40% of export chain production is based on farming contracts between cooperative and exporters. The study focusses on the export chain in which Abogeta-West cooperative is involved. It showed that their upgrade strategies need to be developed for making the avocado flow in formal ways based on farming contracts, because presently, 60% is sold without contracts at low price at the farm gate (average 30 KES/kg) while for the formal average price is 52 KES/kg.

The high losses of avocado production are at the farm level where around 24% do meet export requirements. According to the findings, the main cause is the delay in harvesting when there is no exporter or middlemen who are ready to buy and properly transport avocados, which leads to over-export maturity. Furthermore, harvested avocados must be transported or stored in a cooling truck or room four hours after picking for keeping them fresh and to increase their shelf life. Therefore, this needs to be improved because there is no cold storage available in Meru County. Installing cold storage facilities is the most effective mechanism to extend the shelf life of avocados and reduce transport and storage losses by 30-60%.

The study found a weak relationship between producers and exporters, middlemen and brokers. Information regarding production factors, market, price, quality and standards is managed and retained by other actors rather than farmers. Hence, it is not equally shared among all actors. Farmers are vulnerable and buyers have more power, in addition, farmers do not have access to price and market information. This information gaps need to be addressed for making a win-win avocado business model. 70% of export chain producers are not direct members of any farmer group, and 30% are only Abogeta-West cooperative members either as direct members or via cluster membership (indirect membership). To improve the position of farmers, they could be grouped into farming cooperatives or farmers' groups for being able to increase their bargaining power and to reach avocado value chain coordination.

The research found that Abogeta-West Growers Cooperative Society Ltd has only a marketing role in linking farmers to exporters. This role is not enough for producers' cooperatives. The farmer cooperatives may encourage agricultural technology adoption, increasing crop productivity and farmer income. Cooperative membership is positively related to price, yield, quality, input adoption, and overall income (Ton et al., 2007).

Reliability of institutional governance

Based on research findings, the avocado value chain environment is enabled by well-designed adequate policies and laws to regulate the sector. The only challenges are on the implementation side where all concerned and interviewed institutions showed a shortage of implementing staff. This affects the awareness among stakeholders, especially of actors like farmers and causes a lack of harmonisation for enforcement and updating processes. The situation needs to be ameliorated by making a strong and active stakeholder platform.

The research experienced that there are gaps in the production and accessibility of superior quality and licensed Hass avocado seedlings in Meru County. Improved quality seedlings are produced by public institutions (KALRO) 95 km far from the farmers and they supply only 30% of the farmers' demand. Besides this, farmers can produce their own seedlings. Similarly, Amare et al. (2019) suggested that the Hass variety yields a better price than the Fuerte, which is attributed to the Hass variety's higher resistance to pests and diseases, higher oil content, and ability to conceal bruises. It is also the dominant variety in the large EU export market.

Good seedlings are a key factor for producing superior quality and standardised avocados that meet export market requirements and reducing avocado losses caused by pests, diseases and low environment adaptation. The challenge affects the avocado farm expansion, and this pushes farmers to grow non-licensed Hass seedlings. Because of this, farmers grow poor-quality seedlings which are locally produced with low techniques. This situation needs to be improved for building the capacity of producers' cooperatives and empowering the sector.

The resilience of the Innovation support system

The findings showed that there is insufficient extension services delivery for improving farmers' knowledge and skills in avocado production techniques. The extension services providers claim to have a staff shortage, and, in our days, government does not hire new personnel. The current extension services delivery model is farmer oriented, but the government does not have regular field staff. Farmers are required to request advisory services by writing letters. However, it is not guaranteed that an extension agent will be available. This depends on the season of other crops and the office calendar. In addition, when a public extension agent is available to meet farmers in a meeting, there is often no time to visit farms for a deep assessment of the situation. This is in line with Agyekumhene et al. (2020), who found that farmers in developing countries generally lack access to advanced agricultural inputs, timely market information, and a full range of financial services. In addition, actors' and stakeholders' partnerships both benefit smallholder groups and value chain actors and improve smallholder access to these crucial services (ibid.).

Although smallholder groups allow farmers to adopt farmer-to-farmer extension services where they share their knowledge and skills, it is obvious that they miss new production techniques, information about access to finance, ICT tools needed in agriculture and skills in avocado business plan preparation for achieving the desired avocado production transformation and innovation systems. This situation needs to be addressed by building skilled and strong farmers' cooperatives and stakeholders' platforms.

The current status of avocado value chain sustainability aspects in terms of people, planet and profit for implementing SDGs goals in Meru County

Farmers feel that financial institutions do not trust the sector because their plantation is not insured, and they do not have the collateral for applying for a loan. Thus, they do not plan to collaborate with financial institutions for investments in the value chain. Findings showed that farmers do not participate in avocado price setting which results in low prices at farmgate without considering their production cost, which is not fair.

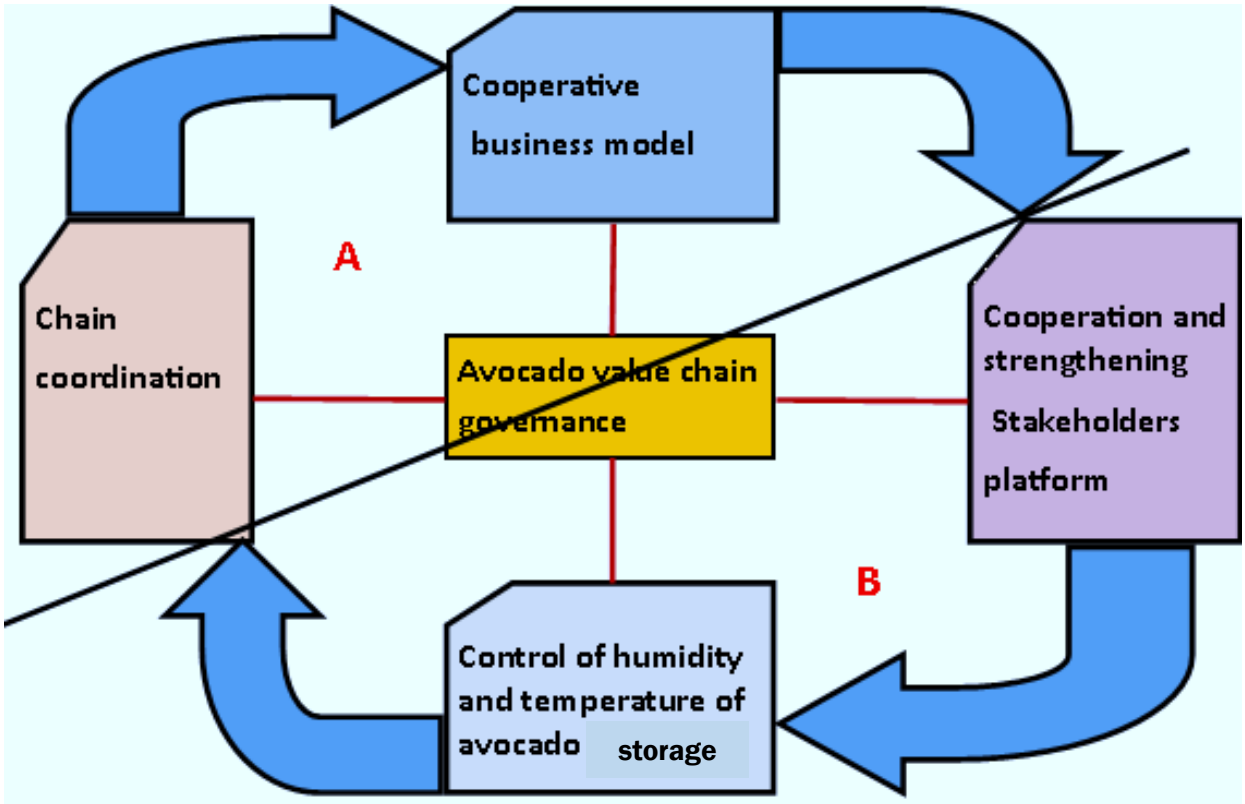
Small-scale farmers produce avocados organically and mix this with other crops which is good for biodiversity. However, their production is not certified as planet friendly. Avocado trees are used for production, but they also control erosion, and they require minimum tillage, therefore, they participate in controlling water runoff.

Women and youth have no access to avocado production resources. The study revealed that, in Abogeta-West cooperative activities, women are involved at the rate of 4% and young men do not own production factors. This hamper improving sustainability and upgrading of the avocado value chain. Avocado tree growing is a men's business in Meru County and the average age of members is 70 years old. The situation could be improved for the business to become more inclusive, sustainable and developed.

Recommendations and interventions

Based on the conclusive findings of this study, it can be concluded that the assessment of the avocado value chain shows leverage points in chain robustness, reliability of institutions and resiliency of the innovation system to develop an upgraded and sustainable avocado value chain governance which significantly reduces avocado losses. Four themes for a model for accelerating the reduction of avocado losses in Meru County are identified. Figure 3 displays the proposed avocado value chain governance framework in Meru County on which recommendations to Abogeta-West Growers Cooperative Society Ltd and FORQLAB project are based.

Figure 3: Proposed 4Cs to improve value chain governance and reduce avocado losses.



Recommendation to Abogeta Cooperative (A)

Theme 1: Chain coordination

Avocado producers in Meru County could be active and direct members of the Abogeta-West Cooperative to secure their bargaining power and improve production factors themselves. The clusters that are members of the Abogeta-West cooperative could be registered cooperatives and every sub-county can have one avocado grower's cooperative. All seven cooperatives could make a cooperative union which is powerful. All individual actors could work in groups and both farmers' cooperatives and other actors can work closely for coordinating the chain. There is a need for employment and application of all available technologies, including ICT technology, to bring about the desired transformation in the agricultural sector in the sub-Saharan region. The only bridge to the desired avocado value chain

transformation can be achieved when all actors are in the group and the chain is coordinated. Facilitating the participation of younger generations could accelerate this process.

Theme 2: Cooperative business model

The Abogeta-West cooperative is now playing the role of linking farmers to exporters. Farmers still face other issues regarding avocado losses, insufficient extension and financial services and low access to improved Hass avocado seedlings. All these challenges could only find appropriate solutions by farmers themselves through their cooperatives which can work as business entities rather than social entities only. The cooperatives could develop business models that create a win-win situation for other actors and farmers to earn together. Business model regarding avocado marketing, processing and superior quality and licensed Hass avocado seedlings can be developed.

For processing avocado, cooperatives need to build a local (cooled) packhouse, organise avocado collection centres in every sub-county and organise adequate transport of avocado production to the packhouse. The packhouse can firstly solve delays in harvesting while waiting for exporters thus lowering avocado losses and secondly can help to increase bargaining power which can result in a better price for avocados in Meru County. There are several options, for example the packhouse can be rented to an exporter with the agreement of collecting avocados on time. Furthermore, from its profit, the cooperative can hire its own extension agents to improve productivity and contribute to the reduction of losses caused by pests and diseases, combined with the production of licensed Hass avocado seedlings.

Recommendation for the FORQLAB project (B)

Theme 3: Cooperation and strengthening stakeholders' Platform

The study found out that, the avocado value chain has stakeholders who know their responsibilities to develop the chain, but they are not in an active and strengthened platform where they can share challenges and find solutions together. It is recommended to focus on that part for making a deep assessment of the case and helping in the establishment of an active avocado stakeholders' platform.

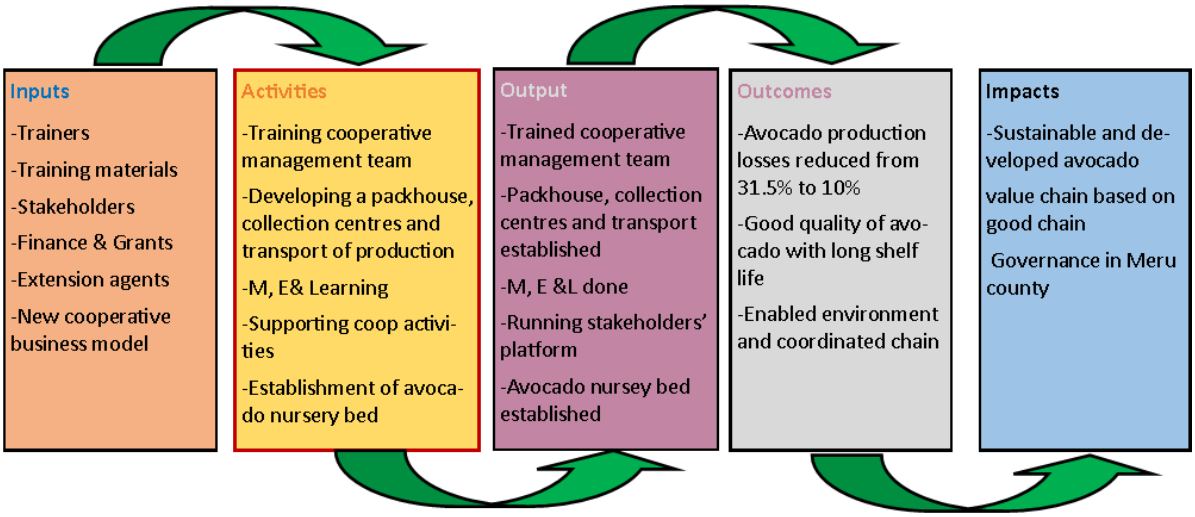
Theme 4: Control of temperature and humidity of avocado production

The cooperative management team needs improved skills in post-harvest handling of avocado production. The skill-gaps among leaders who train farmers through the farmer-to-farmer extension model are related to controlling temperature and humidity in harvested avocados. They still harvest avocados and keep them under fresh banana leaves, sometimes more than two days before transportation. This is a major problem even when the cooperative will have an adequate Parkhouse. It is recommended to train at least a cooperative management team and empower them with enough skills to control the humidity and temperature of avocados for increasing shelf life.

Proposed interventions

To reduce avocado losses in Meru County, the construction of a local avocado packhouse and collection centres and organised adequate production transport are the main solutions. In addition to coordinated VC and active stakeholders' platform as part of chain governance, can be a sustainable solution for the reduction of avocado losses in Meru County. Figure 4 shows the proposed interventions.

Figure 4: Proposed interventions in the theory of change



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

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Practice Brief
FORQLAB Project 2022-07

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

van hall larenstein
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Introduction

The avocado market is flourishing globally (Naamani, 2011), with a fast-increasing demand being observed in the European market (Takadi, 2018; Amare et al., 2019). The global demand is anticipated to triple in the next five years before reaching stability. Yet the current top producers and suppliers in the world market (Mexico and Colombia) may not be able to meet desired quantities throughout the year (Statista, 2022), due to weather conditions and short harvest periods (Motaung, 2019; Naamani, 2011; Bustos and Moors, 2018).

This offers a high potential to Kenyan avocado value chain to competitively capture the global markets because of the favourable climatic and environmental conditions that facilitate production throughout the year (Muthomi, 2019; Ringo et al., 2022). Moreover, in Kenya, avocado is ranked as the fourth important national fruit crop and number one fruit being exported to European and middle East countries (Ringo et al., 2022). Besides, the crop provides livelihood to over 85% of the Kenyan small-scale farmers and generate forex revenue to the Kenyen economy (Wasilwa et al., 2004).

However, the value chain is faced with various challenges leading to high food losses approximately over 50% (pre- and postharvest food losses) along the chain (Skoet et al., 2020). Food losses are defined as any food (avocadoes) leaving the export and local avocado chain due to abnormal intrinsic and extrinsic reduction in quality and quantity such as rotting, wilting, bruised, getting spoilt, spilled and or else disappearing before reaching the final consumers (Lipinski et al., 2013).

Gustavsson et al. (2011) suggested that food losses should be estimated for every stage of the chain from on farm activities to consumption, because quantitative and qualitative food losses differ at every stage. According to Parfitt et al. (2010), highest food losses in the Kenyan avocado are evident in harvesting stage (Parfitt et al., 2010).

Stages with higher amounts of food lost are indicated as hot spots. They cause significant environmental impacts, such as greenhouse gas emissions, and water consumption (FAO, 2013). Identifying and addressing causes of food loss helps stabilize the value chain, and reduce environmental footprint of food systems (FAO, 2019). Studies conducted by Xue et al. (2021) suggest that causes of food loss are related to poor management and governance, inadequate technologies for various operations at every stage, institutional factors, and the socio-economic status.

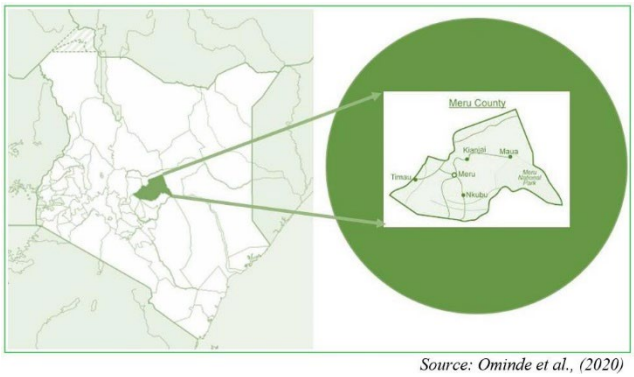
Objective

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

Methodology

The study was conducted in Meru County, Kenya, which is situated at the eastern highlands of Mt. Kenya at an elevation of about 53.000 feet above sea level which is favourable for avocado production (Ominde *et al.,* 2020) (Figure 1).

Figure 1: Research location Meru County in Kenya



Source: Ominde et al., (2020)

In depth information about food losses in the avocado chain and possible interventions to reduce losses, was found by using multiple research methods:

- A questionnaire with 40 actors in the chain;
- Semi-structured interviews with different chain actors: farmers, brokers, processors/exporters, wholesalers, retailers and supporters (KEPHIS NARIGP, KALRO, HCD, Avocado society of Kenya);
- Three focus group discussions (FGDs): 1 FGD with 8 cooperative management team members, 1 FGD with 12 farmers that were partially member of the cooperative and partially were not, and 1 FGD with 10 chain supporters;
- Observation;
- Desk research.

All stages of the avocado value were investigated. In table 1 the research questions and research methods are summarized.

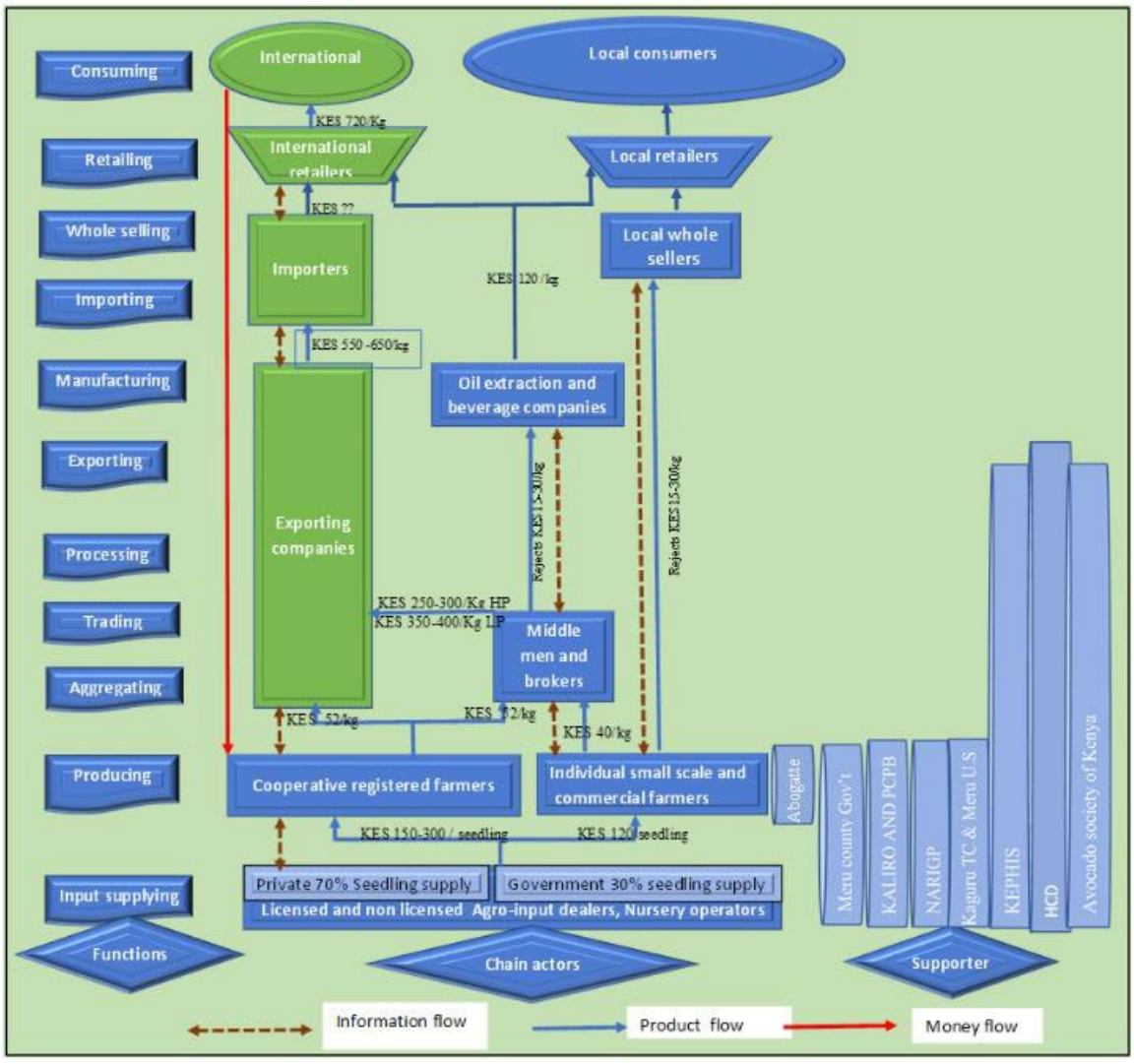
Table 1. Summary of research methods used and tools

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

Findings and discussion

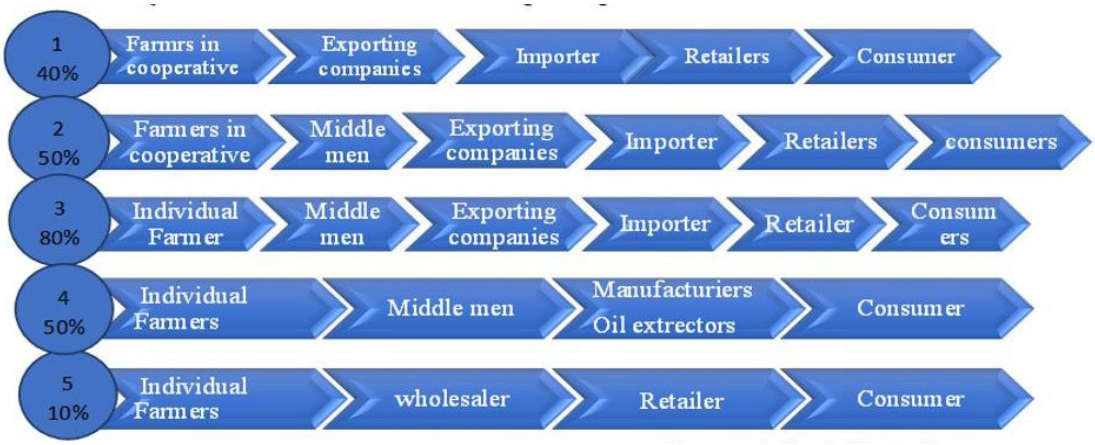
Avocado value chain in Meru County (Figure 2)

Figure 2. Avocado value chain in Meru County



The quantities of avocadoes going through different channels differs (Figure 3). Most of the avocadoes (50%) in Meru County go through channel 4, which is directly from individual farmers to middlemen to manufacturers / oil extractors and then to both local and international consumers.

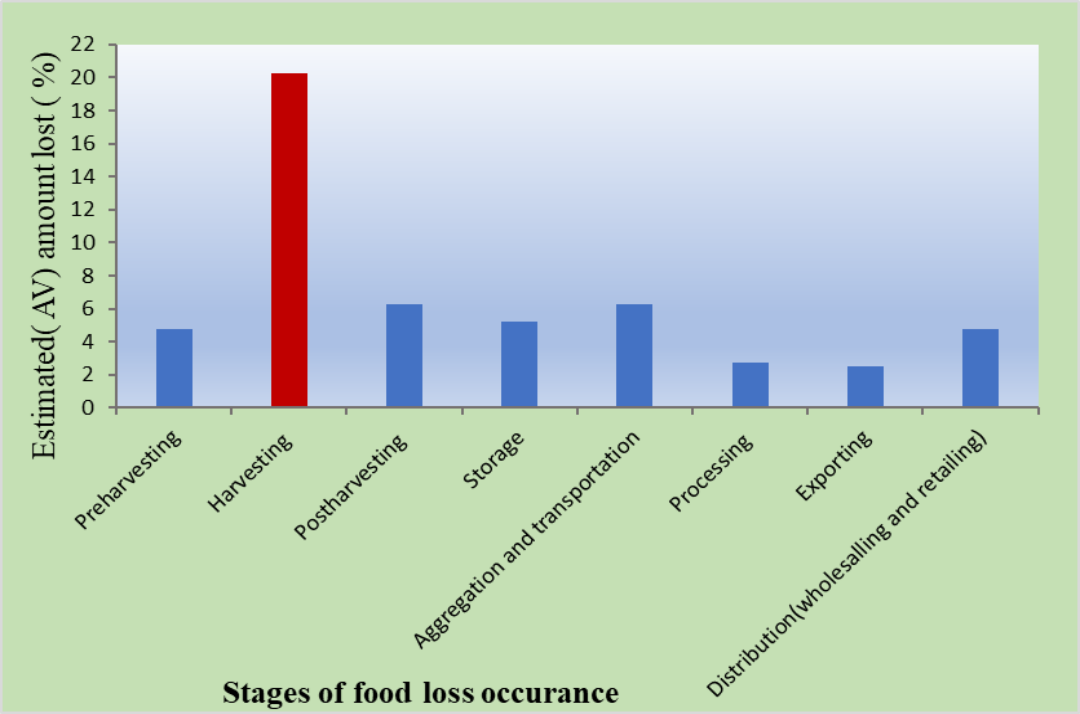
Figure 3. Quantities and channels through which Meru avocados flow



Food loss quantities

The study found estimated losses at different levels of the value chain (Figure 4).

Figure 4: Food loss per stage of the avocado chain



A food loss of 5% and above was considered as a hot spot. Obtained results show that food loss hotspots exist in harvesting (20.25%) followed by post-harvest handling (6.25%), aggregation and transport (6.25%), distribution (5.25%) and storage (5.25%). Therefore, especially high food loss is incurred during harvesting.

The high losses during harvest could be attributed to poor harvesting techniques, use of unskilled labour, and inadequate knowledge on market requirements. Majorly small-scale farmer, brokers or traders use manual unskilled labour who have minimal knowledge on harvesting methods, size requirements and maturity detection. Poor harvesting techniques can lead to lenticel damage, breakages of dropping of unintended fruits, sunburns, malformation, manifestation of pests and diseases that most harvesters are not able to recognize (Ramírez-Gil et al., 2019).

During aggregation and transport, losses occur because most avocados are sourced from small scale farmers who do not have a central collection point. Freshly harvested fruits are aggregated from farmer to farmer. The fruits are packed in bulk and transported in open trucks (non-refrigerated) through rough roads. Those conditions subject the fruits, mechanical damages, bruises, and deterioration due to heat.

Distribution losses occur because traders and wholesalers lack storage and cooling facilities where the fruits can be kept as they await distribution. The products are kept in the open trucks or sacks, exposing them to harsh weather conditions. As a result, fruits get sun burns, mechanical damages and reduction in shelf life (Ramírez-Gil et al., 2019).

Most farmers, traders and middlemen do not have storage facilities either, which leads to early deterioration and therefore storage losses. On farm, harvested fruits are kept on ground under trees (picture 1U) or old buildings (picture 1V), exposing the products to contamination and unfavourable climatic conditions such as high temperature (picture 1W). Temperature is a critical aspect that plays a role in the product shelf life.

Pictures 1U, V and W. Avocado postharvest handling and storage methods practices by some farmers

Key informants indicate that occurrence of food losses is more on-farm than off-farm.
On-farm food losses include especially losses due to pests and diseases. Farmers have limited access to extension services resulting in poor farm management. Climate change has worsened the situation because of the introduction of invasive pests and diseases. Pest and disease control also requires approaches with less adverse effort to food and environmental health.
The current strategy of farmers organizing themselves to a cooperative association to demand for services is yielding positive results because organized farmer cooperative or associations have a higher bargaining power compared to individual. Secondly, it is easy to reach and deal with groups of farmers with the limited resources and engage in agreements (Mwaniki and Nyamu, 2022).
The cooperative is now training youth in harvesting techniques. However, the adoptability and youth engagement are very low due to the quest for quick income that has pushed most youth to urban areas.

Factors influencing food losses in Meru avocado value chain

Many socio-economic, institutional, technological, and environmental factors that lead to avocado losses were found (Table 2).

Table 2. Summary of factors influencing food loss along the avocado value chain

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

Economic and environmental losses

The amounts of avocadoes produced in Meru County are not known. However, farmers are highly economically impacted by loss as most losses occur at farm level. As the selling price of the Meru avocadoes increases along the chain (Table 3), higher up in the chain also a small loss percentage can lead to a high value of economic loss. Moreover, accumulative food losses directly impact on the country's Gross Domestic Profit (GDP).

Table 3. Estimated economic losses from food loss along the Meru avocado value chain

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

According to key informants, about 25% of the country's total avocado production is produced in Meru County. Based on national data, the avocado production in Meru County is therefore estimated to be around 80.65 MT. And the total amount of avocadoes food loss in Meru County is estimated to emit a remarkable amount of about 6882.66 kg carbon equivalent (Table 4).

Table 4. Estimated carbon emission caused by loss of avocadoes from Meru County

Stage of the value chain	Available amount (MT)	% Loss	Lost amount [MT]	lost amounts [kg]	Carbon footprint [lost amount *0.19]
Production	80.65	31%	25.0015	25001.5	4750.29
Aggregation & transportation	55.6485	11.50%	6.399	6399	1215.81
Processing	49.2495	2.75%	1.354	1354	257.26
Exporting	47.8955	2.50%	1.182	1182	224.58
Distribution	46.7135	4.75%	2.288	2288	434.72
					6882.66

Besides the emission of carbon, food losses also impacted biodiversity loss, extreme climatic conditions as well as soil degradation.

Current strategies for reducing food losses by stakeholders of the Meru County avocado chain

Table 4 outlines interventions and strategies implemented by some involved stakeholders at different stages of the chain.

Table 4. Current strategies to reduce losses for Meru County avocadoes

Actors/supporters	Current strategies/intervention to reduce food losses
Producers	Organized themselves into small farmer groups and cooperative to create market linkages. Collaboration with input suppliers for acquisition of necessary inputs and services such as pesticides and extension services. Training youth in harvesting and handling of the product. Used of harvesting equipment (Only among few commercial farmers)
Aggregators	Transportation of the product in closed roof trucks (Mainly done by brokers, traders and company agents).
Processors/exporters	Use of automated equipment for various processes. Use of well-trained personal in handling and processing Established storage areas
Supporters (KEPHIS, HCD, PCPB, FPEAK, NARIGP)	Development of regulations Development of platforms for open discussion Offer extension services. Regular inspections Certification

As a result of economic and social losses due to high loses in the avocado value chain, some farmers are organizing themselves into small farmer groups and cooperative to create market linkages for acquisition of inputs such as pesticides, seedlings, harvesting equipment and extension services.
Some exporters who signed contracts with organized farmer groups have initiated the aggregation and transportation avocados in closed roof trucks together with continues farmer training on crop management, handling, and recommended harvesting techniques.
The government has development of regulation, platforms for open discussion and inspections.
However, more collaborative business to business module should be developed to facilitate a more sustainable food loss reduction approach along the Kenyan avocado value chain.

Conclusions

1. Stakeholders have a wide range of roles. Together, they have high potential to reduce food losses and meet the international demand. However, policy strengthening and stronger collaborations for better resource mobilization is required.
2. The chain has existing governance structures, but weak chain relations among actors are a major hinderance to the smooth flow of the products and market information. Furthermore, the chain resilience in terms of capacity to overcome or resist disruptive occurrences, for example from climate change, have not been instituted. Reliability of the chain in terms of regulation and legislations has been tackled by government but less attention has been offered toward their implementation.
3. Food losses occur at all stages of the chain, but losses are more pronounced at harvesting (20.25%) due to poor harvesting techniques and inadequate knowledge among harvesters. This is followed by the stages of aggregation, transportation and distribution that are each contributing 6.26% to food losses due to inappropriate transportation facilities. Storage is another hotspot with 5.25% food losses due to poor or lack of storage facilities, especially among farmers and aggregators.
4. Various environmental, socio economic, technological, and institutional factors were identified to influence food losses along the chain. It was found that the major constrains to reduce food losses are inadequate technologies for handling the products especially among farmers and aggregators like cooling systems, appropriate transportation and packing materials. Secondly, there are weak institutional structures such as the poor organization among involved actors. This impacts chain

relations and trust among actors. Another critical issue is the weak policy implementation and inadequate governance structures for monitoring and reinforcement of the existing regulations.

5. Huge amounts of avocadoes are lost in the chain. The lost amounts increase inefficiency of the resources since high inputs are used for production. Besides high input use, lost mount increasingly exert pressure on the environment through greenhouse gas emissions. The food loss amount observed in Meru are contributing significate amounts of carbon footprint calculated at 6882.66 kg of carbon equivalent.
6. Currently implemented food loss reduction strategies are supportive in reducing food losses along the value chain. Training of youth to carry out harvesting and continuous training of farmers is important. However, more incentives should be planned for, to motivate youth engagement in the sector. Additionally, continuous training and sensitization on minimum handling and transportation should be planned for by the relevant authorities. Finally, for implementation of developed policies more effort is required to ensure better understanding. Besides, adherence to policies remains a challenge.

Recommendations

To reduce food losses, ensure sustainability and profitability along the Kenyen avocado value chain interventions need to be taken by the involved actors and the SIA project for Food Waste Reduction and Food Quality living lab:

- Chain upgrading through vertical and horizontal integration to develop formal producer groups and engage in contractual farming with exporters and manufacturers and further engage various activities to reduce food losses along the chain. A specific recommendation for the cooperative is to work toward building more private-public collaborations through coordination, accountability, and transparency to enhance trust building among stakeholders and further source funding and appropriate technology for intended processes to enhance food loss reduction.
- It is recommended to work on capacity building of farmers and the cooperative. Capacity building of the cooperative can strengthen internal capacity and promote the development of stronger governance structures. These will improve market information access, analysis, and dissemination. Further, these will promote production based on the market requirements and it will offer the cooperative higher bargaining power.
- According to key informants, the cooperative has received funding for constructing a pack house. It is recommended that the spearheading team and the management of the cooperative ensure that the establishment and operationalization of the pack house is achieved within the next 2 years through collaborative planning, development of the guidelines and commitment to achieving them within the set period. The packhouse can greatly enhance reduction of food losses associated to poor storage and poor transport facilities.
- The government and other supporters are advised to consider strengthening the implementation of the existing policies through continuous capacity building of involved stakeholders and to set up monitoring and evaluation mechanisms.
- SIA, through Food waste Reduction and Food Quality living Lab (FORQLAB), should develop a business-to-business approach that ensures sustainability of partnership with involved stakeholders. It is recommended that the business model outlines operational agreements that cover technical and financial support.

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Scaling mechanisms for avocado loss reduction in Meru County, Kenya

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Practice Brief
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FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

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Introduction

Avocado (*Persea americana Mill*.) has shown to be a highly lucrative commercial crop for Kenya for both the export and the domestic market (Mokria et al., 2022). Kenya's avocado production 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, Kenya's avocado export significantly increased (Johnny et al., 2019). Reduction of postharvest losses is increasingly recognized as crucial to the sustainability of food supply chains. Perishability presents a serious challenge in efforts to mitigate food losses (Wakholi et al., 2015). Food losses impose enormous economic, environmental, and social costs (Meyer et al., 2017; Bustos and Moors, 2018).

In Kenya, approximately 15% of avocados are lost in the export supply system between farm and consumer, while for the domestic market approximately 35% of avocado's harvested are lost before being consumed (Snel et al., 2021). In Sub Saharan Africa, insufficient harvesting technologies, poor handling and improper storage has been attributed to 68% of total postharvest losses (Kaminski and Christiaensen, 2014). In Kenya, reduced food losses are among the key priority areas at different levels of production and post-harvest supply chain stages (Verschoor et al., 2020).

Several measures were already taken in Kenya to reduce avocado losses and improve quality, including the establishment of fruit processing companies, training of farmers on harvest handling techniques and post-harvest handling of avocadoes, and introduction of reefers (Snel et al., 2021).

Nevertheless, Kenya has been facing challenges with avocado losses. These challenges are caused by for instance weak governance in export and domestic markets (Matui et al., 2016), weak coordination of fruit export (Dengerink and Rijn, 2018), lack of market information and transparency (Snel et al., 2021), weak capacity of small-scale producers to improve accountability and quality of the avocados (Dengerink and Rijn, 2018), limited organisation of avocado farmers into producer organizations and limited contractual arrangements with buyers (Rampa & Dekeyser, 2020) as well as limited entrepreneurial and internal governance capabilities of cooperations (Kessler et al., 2020).

Research objective

It was not known to what extent avocado loss reduction practices are implemented and used among actors in Meru County, Kenya. Therefore, the objective of this study was to assess the existing loss reduction practices, and to identify, analyse and develop interventions to promote implementation and utilization of best practices, as scaling mechanisms for reducing avocado losses in Meru County.

Methodology

The study was explored through linking the concepts value chain governance and scaling mechanisms, with the aim of identifying possible interventions for scaling avocado loss reduction in Meru County.

Scaling is hereby defined as the set of strategies and approaches aimed at ensuring that the inventions,

innovations, and developments benefit a broader scope of people and situations (Wigboldus, 2016). Identifying scaling mechanisms is seen as key input into successful interventions (Wigboldus and Leeuwis, 2013). Successful scaling processes commonly necessitates involvement with all aspects of a governing regime and bringing different kinds of actors together (Steenbergen et al., 2022), often using participatory and collaborative interactions between stakeholders (Granstrand and Holgersson, 2020).

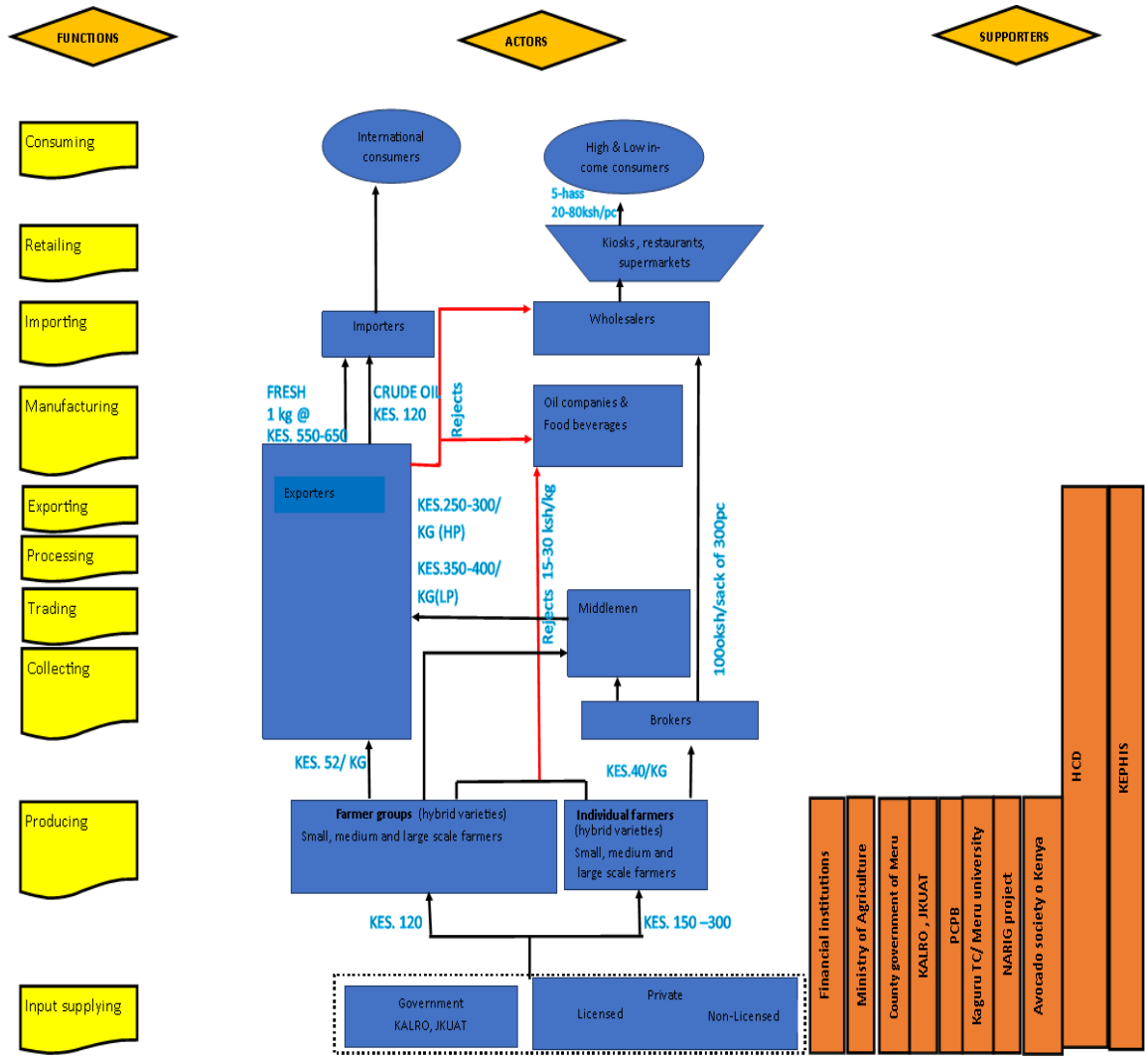
For this study information was gathered from many and diverse stakeholders in the Meru avocado chain through interviews with 33 key informants and 2 Focus Group Discussions (FGD) with the Abogeta West Avocado Cooperative which is the largest avocado cooperative (500 members) in Meru County.
The interviews were held with key informants from the National Agricultural and Rural Inclusive Growth Project (1) that has avocado as one of their target crops, 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). Furthermore, interviews were held with the following chain actors: input suppliers (3), middlemen (2), brokers (2), processors (2), exporters (2), oil extractors (1) and retailers (5) as well as individual farmers (5) who were not members in any producer organizations.
The first FGD was with 6 management team members of the Abogeta West Avocado Cooperative, of which 1 female. The second FGD was with 8 cooperative members, of which 1 female.

Research area Meru County
The research area is located around the slopes of Mt. Kenya and is well known for its production and export of horticultural crops. Meru county has a relatively good climate for avocado growing and is among the leading producing areas in Kenya (Githiomi, 2019). Cultivation is predominantly through rain-fed agriculture. Avocado varieties most cultivated in Meru are Hass and Fuerte. Other varieties, such as Pueblo perform exceedingly well above 2500 meters within the County.
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 (Masinde, 2022). The large-scale farmers also supply avocado to the middlemen who export. Most of the small-scale avocado farmers are between the age of 57-75 years according to the Abogeta West Cooperative Society.
There are numerous challenges that the Meru avocado farmers encounter 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 (Masinde, 2022).

Meru's avocado value chain

The stakeholders in the Meru avocado value chain are represented in the value chain map (Figure 1).

Figure 1: Avocado chain map of Meru County. Adapted from information from respondents



Individual farmers commonly sell through brokers. Farmers groups such as Abogeta West Avocado Growers' Cooperative Society also link farmers directly to the export market through promotion of production and marketing.

There are many supporters active in the sector. Specific supporters that play an important role of linking the farmers to the market are the Avocado Growers Association of Kenya (AGAK) that coordinates producer organizations and links producers and exporters, the Horticultural Crops Directorate (HCD) that regulates avocado quality from production to export, and the Kenya Plant Health Inspectorate Service (KEPHIS) that monitors and educates farmers and exporters on quality standards and safety issues (Ringo et al., 2022).

Best practices to reduce avocado losses

Literature shows the following practices are important to reduce avocado losses.

Technical practices to reduce avocado losses

- Production

Right environmental conditions should be maintained, and good agricultural practices used (Balogh et al., 2021). For instance, inputs such as fertilizer, herbicides and pesticides must be provided in correct amounts, where and when needed (precision farming). This also enables better planning for harvest and logistics.

- Harvest

As avocado fruit ripens after harvest, it is picked when mature but unripe to withstand postharvest handling like transportation (Kassim et al., 2013). Harvesting should be done at precisely the right maturity stage (Erkan and Dogan, 2019). Harvest maturity of avocadoes can be determined by testing representative samples on indices as mesocarp oil, dry matter, or moisture content (Magwaza and Tesfay, 2015). Dry matter content is determined by drying in an oven at 70°C or in a microwave oven (Magwaza and Tesfay, 2015). The minimum required 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). Avocado fruit's nutritional value is commonly determined by high oil content (Donetti and Terry 2014). The harvesting method has shown to affect the postharvest fruit quality (Hernández et al., 2016). Avocado should be harvested without mechanical damage, as this can degrade the appearance and serve as an entry point for postharvest pathogens that cause decay during storage and transportation (Singh and Sharma, 2018). To avoid damage, avocado is typically placed in either a soft picking bag tied to a harvesting pole or placed into a plastic crate (Bill et al., 2014).
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. 'Fuerte,' variety 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). When clippers are used to harvest the fruits, about 1 cm of the pedicel should be left attached to the fruit (Kassim et al., 2013).
Avocadoes must be put in the shade straight after harvest to reduce weight loss due to moisture loss, and to reduce ripening and shortening of shelf life (Bill et al., 2014). Using proper ladders also reduces damage. The avocado handlers should be trained on the best way to harvest, store, and package avocado products to reduce harvest losses (Bustos and Moors, 2018).

- Precooling

Avocadoes must be pre-cooled to about 16 °C as soon as possible after harvest to remove the field heat and thus delay ripening (Arpaia et al., 2015). 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

Temperature regulation of the transport system is important in reducing losses. To reduce losses during transport, use can be made of wooden or plastic racks in the truck to allow air circulation and minimize heat buildup or by using environment-controlled trucks (Kimaro and Msogoya, 2012; Kereth et al., 2013).

- Cooling and storage

Temperature management preserves the quality of avocados, lowering qualitative and quantitative losses, and extending their postharvest life (Bill et al., 2014). Avocadoes benefit 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

Processing reduces avocado losses by extending shelf life and as the avocadoes 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.
Burton & Bamber, an agro-processing company in Thika, produces dried fruit with brand name Sweetunda, made from residues that would otherwise be wasted and thereby contributes to the reduction of post-harvest losses (Matui *et al.*, 2016).

Methodological practices to reduce avocado losses

- Individual and collective capacity building
  Capacity building in decision making and strategic planning for stakeholders creates increased awareness and behavioural change, leading to enabling conditions to reduce losses (Wigboldus and Leeuwis 2013). This is an essential area for investment in guiding responsible scaling in agricultural development (Wigboldus and Leeuwis 2013).

- Public-Private partnerships (PPPs)
  PPPs have proven to be successful in tackling food losses (Reynolds et al., 2019; Matzembacher et al., 2021). PPPs can provide more efficient, adaptable, and effective regulatory structures than traditional regulatory structures because they can be more cost-effective and have a greater impact (Abbott and Snidal, 2021). PPPs facilitate collaboration between stakeholders and supply chains and highlight the best practice approaches as well as identifying the most appropriate lead organization (WRAP, 2019). Besides, PPPs have enough resources to assist signatories in meeting targets and developing new ones (WRAP, 2019).

- Citizen behaviours change campaigns
  Reynolds et al. (2019) mentioned that citizen behaviour change campaigns approaches are effective. Vlaev *et al.*, (2019) suggested that policymakers should use additional regulation interventions and economic instruments to effectively support citizen behaviour-change campaigns as part of a national food strategy for an integrated approach to food loss. Monitoring and evaluation are advised to allow for adjustments to further improve food loss.

- Learning and knowledge platforms
  Knowledge and innovation platforms facilitated and supported learning and creating change as they bring actors together to share knowledge and find solutions to problems (Kessler et al. 2020; Misiko et al., 2013; Cadilhon, 2013; Homann-Kee Tui et al., 2013). 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.

- Participative extension approaches
  Approaches such as farmer to farmer, and farmer field school, rural resource centres and relay organizations and innovation platforms can assist in spreading innovations (Neufeldt et al., 2015; ICRAF, 2015). To increase practice adoption, farmers must be involved in the development of new technologies from conception to distribution. Besides, facilitation of farmer groups and building their technical capacity is needed (Bertin et al., 2014).
  Farmer trainers recruited from existing farmer groups which are trained in technology, communication, and capacity-building skills are most effective in dissemination of simple

technologies (Lukuyu et al., 2012). More women farmers can be reached by selecting female farmers for extension roles (Simpson et al., 2015).

There is a significant gap between knowledge dissemination and adoption. However, projects are frequently designed to train a specific number of farmers to adopt specific practices (Matui et al., 2016). Technology demonstrations are more effective for development then knowledge development (Matui *et al.*, 2016).

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 on the longer run (Franzel et al., 2015).

Current practices to reduce avocado losses in Meru County

The interviews with key informants and the FGDs revealed that according to the stakeholders the following practices can positively influence reduction of avocado losses in Meru County.

- Technical practices:
  - Use of certified seedlings.
  - Limited application of pesticides to large scale farmers.
  - HCD and KEPHIS inspections to monitor adherence to regulations and phytosanitary procedures by the actors.
  - Agriculture and Food Authority (AFA) regulations regarding harvesting time at right maturity, manual harvesting.
  - Use of crates for transportation.
  - Precooling at packhouse.
  - Cold storage.
  - Mobile applications of established knowledge and innovation platforms to help farmers in the production of different crops including avocado.

- Methodological practices:
  - Training and capacity building.
  - Farmer driven extension services by Kaguru Agricultural Training Centre including Farmer Field School (FFS) approaches.
  - Self-organised farmer groups that disseminate knowledge amongst themselves.
  - Private Public Partnerships.
  - Farmer field schools (FFS).
  - Manual traceability system from source to importer implemented by exporters, that traces on farmer name, harvesting date, time, variety, and if applicable farm block.

It was found that the degree to which practices contribute to the reduction of postharvest losses, depends on factors such as regulatory frameworks and government policies being in place, knowledge, and motivation.

Stakeholder matrixes regarding roles to reduce avocado losses

Results from the interviews with key informants and the FGDs showed that the avocado value chain actors and supporters in Meru County have different roles in relation to reducing avocado (Tables 1 and 2).

Table 1: Avocado stakeholder matrix of Meru County for the actors in the chain

Actors	Current roles and functions aimed at reducing avocado losses	Categories
Input dealers	Inputs provision of e.g. fertilizers and pesticides to reduce pest and diseases, 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 like 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.	Categories farmers according to FDG: Small (1-50 trees) Medium (51-150 trees) Large (151 trees 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 seedlings. 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: local varieties. International wholesalers: hybrid varieties
Retailers	Adoption of post-harvest handling and management practices	95% women. Includes kiosks, supermarkets, and roadside sellers

Table 2: Avocado stakeholder matrix of Meru County for the supporters

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. Extension 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

SWOT analysis avocado sector

Table 3 presents the views of the interviewed key informants and the farmers in FGD discussions about current strengths, weaknesses, opportunities, and threats of the avocado sector in Meru County.

Table 3: Avocado SWOT Analysis in Meru County

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

Findings and discussion on enabling and disabling factors to reduce avocado losses

Within the Meru avocado chain

- Use of uncertified avocado seedlings Most farmers use avocado seedlings acquired from informal local nursery growers instead of seedlings from formal certified growers. Thereby, farmers use avocado varieties that are susceptible to pest and disease which eventually lead to enormous pre and postharvest loses. Extension takes place to create awareness to farmers about this problem. Nevertheless, farmers keep using the uncertified, local seedlings. This is probably due to inadequate financial capacity of the farmers to afford certified planting materials.
- Labour constraint. Farmers seem to suffer from a labour constraint, which might hamper the farmer's commitment to implementing avocado loss reduction practices.
- Insufficient availability of extension services. This contributes to the high pre- and postharvest losses during production.
- Avocado producers lack adoption of best practices for avocado loss reduction. This is probably influenced by the older age of most small-scale producers in Meru's avocado value chain.
- Lack of proper post-collection and handling practices. Middlemen and brokers are the main collectors of avocadoes from farmers and supply to exporters in the chain, forming the link between farmers and exporters. However, middlemen and brokers contribute to losses in the chain due to lack of proper post collection and handling practices.

Concluding: 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.

This results in huge losses of avocado during the production and transportation phases of the value chain. The avocado producers appear not to be properly trained in avocado handling which renders their role in avocado loss reduction almost insignificant.

Other actors up in the chain, particularly exporters, manufacturers, wholesalers, and retailers claimed to provide extension and training support to producers as the principal source of the product for their bushiness. However, this does not seem to reflect the current situation as seen by the producers in Meru County.

Role of supporters in reducing avocado losses

An elaborate list of supporters playing various roles in the avocado value chain of Meru County was found. However, this study has also demonstrated that the common role played by the identified supporters in avocado loss reduction is basically limited to extension and training of farmers.

However, this support role is not recognised by the Meru avocado producers. They state extension and training by supporters is neither adequately provided nor meeting their collective needs.
A cause for the limited training and extension is that most supporters interviewed such as the Kenya Plant Health Inspectorate Service (KEPHIS) and the County Government of Meru lamented the problem of insufficient staff. Therefore, these supporters cannot provide regular training and extension support to the avocado producers.
Besides, although the supporters of the Meru avocado value chain partner with the community to produce quality seedlings, provide subsidized seedlings, and link farmers to markets to ensure reduction of avocado losses, most farmers do not appear to fully benefit from these support initiatives.
Furthermore, although financial institutions such as Equity Bank and Kenya Commercial Bank provide credit facilities to avocado growers in Meru County, most of the farmers do not have collaterals to enable them to qualify for loans. Besides, Meru County farmers lack motivation to access financing to quality inputs, equipment and machinery that can improve avocado production and quality.
Therefore, it can be stated that supporters also do not provide other support like providing subsidized seedlings, linking farmers to markets, and providing financing for production to ensure reduction of avocado losses.
However, value chain support functions focused solely on improving farmer's knowledge without providing an enabling environment for adoption and application of that knowledge will probably not succeed in achieving the desired outcome of reducing avocado losses in the chain.

In general, it can be stated that practices to scale avocado loss reduction are influenced by several factors such as inadequate knowledge, lack of motivation and resources by the farmers, as well as adequate regulatory frameworks and government policies. An integrated approach of scaling avocado loss reduction needs to be considered.

Conclusions

1. **Enabling factors** to scale avocado loss reduction are expansion of international markets, increased development partners and high revenues. These factors can encourage the scaling of avocado loss reduction.
2. **Disenabling factors** include farmer's lack of equipment for harvesting and determining maturity, high incidence of diseases and pests, poor transportation methods, poor pre-harvest storage systems, and insufficient extension services.
   Good practices to prevent losses in especially the pre-harvest phase like use of certified seedlings, pesticides regimes, and transportation methods are not well established and implemented.
   However, good current technical practices are a proper harvest time and well implemented storage of avocadoes at the processing stage.
3. **Chain actors do not do enough to reduce avocado losses**. As a result, high losses occur at production level.
4. **There is insufficient assistance from the chain supporters** for implementing best practices and thereby reducing avocado losses.
   Extension services are insufficient as there is only limited extension and training of part of the farmers. Furthermore, supporters do not do enough in providing other support such as inputs, equipment and machines for harvesting, processing, and storage.
5. **Much more needs to be done to scale avocado loss reduction along the chain but current mechanisms for scaling up avocado loss reduction in Meru's avocado value chain are inadequate.**
   Implementation of technical and methodological practices for scaling up avocado loss reduction is very limited.
   Methodological practices such as extension services, trainings and private public partnerships can be used to scale avocado loss reduction. However, these are not sufficiently provided to the actors.
   There is also insufficient vertical and horizontal coordination and collaboration among chain actors

and supporters to adequately scale up avocado loss reduction practices.
There is a lack of harmonization and enforcement of policies for loss reduction among supporters at national and county level.
Furthermore, 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.

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.

Table 4 shows the detailed plan for the proposed recommendations. It presents the activities, required inputs, stakeholder involved, how often and where the activities will take place.

Table 4: Theory of Change for proposed interventions

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

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Reducing Food Loss and Waste in the Kenyan-European Supply Chain

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Practice Brief
FORQLAB Project 2023-01

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

HAS green academy

1. Executive Summary

This practice brief provides a comprehensive analysis of food loss and waste (FLW) in the avocado supply chain from Kenya to Europe. Kenya is a major producer of avocados, yet it faces significant challenges in quality consistency, logistics, and compliance with European Union (EU) standards. Addressing these challenges is essential for Kenya to establish itself as a competitive and sustainable avocado supplier to the EU market. This document outlines the primary findings and actionable recommendations to optimize Kenya's avocado supply chain, including infrastructure enhancements, stakeholder collaboration, and improved quality management practices.

2. Background and Context

2.1 Global Avocado Demand and Kenya's Market Position

The global demand for avocados has grown consistently in recent years, driven by increased awareness of their nutritional value and versatile use in culinary applications. While countries like Peru and Mexico dominate the avocado export market, Kenya has emerged as an important supplier to Europe due to its favorable growing conditions and competitive pricing. Despite this, Kenyan avocados often face quality consistency issues that hinder their competitiveness in the EU market.

2.2 Food Loss and Waste (FLW) in the Kenyan Avocado Supply Chain

The avocado supply chain in Kenya is characterized by a high incidence of FLW, particularly in the pre-export stages. FLW occurs due to several factors, including:

- **Insufficient cold chain infrastructure** leading to quality degradation.
- **Inconsistent harvesting and handling practices** among smallholders.

- **Extended and indirect shipping routes** that exacerbate over-ripening.
- **Lack of standardized quality control** mechanisms from farm to export.

Reducing FLW in this supply chain would not only improve profitability for Kenyan farmers but also contribute to broader environmental and sustainability goals by minimizing resource waste.

3. Research Objectives and Methodology

3.1 Objectives

This study was designed to:

- Identify the primary causes of FLW in Kenya's avocado supply chain.
- Analyze market requirements in the EU and evaluate Kenya's current compliance.
- Develop actionable strategies to reduce FLW and enhance Kenya's competitiveness.

3.2 Methodology

The study used a multi-method approach involving:

- **Stakeholder Interviews**: Interviews with avocado growers, cooperatives, exporters, and EU importers to understand challenges and potential improvements.
- **Field Observations**: Detailed observations of handling, storage, and transportation practices across various stages of the supply chain.
- **Secondary Data Analysis**: Review of EU market data, competitor analysis, and Kenyan avocado production statistics to contextualize findings.

4. Key Findings and Analysis

4.1 Variability in Avocado Quality

Kenyan avocados exhibit considerable quality variation due to the decentralized nature of production among smallholder farmers. Key issues include:

- **Lack of uniform harvesting standards**: Harvesting decisions are often based on immediate market prices rather than optimal ripeness, leading to inconsistent quality.
- **Insufficient Training**: Many smallholders lack knowledge about the optimal practices for harvesting, handling, and storing avocados to preserve quality.

4.2 Insufficient Cold Chain and Storage Infrastructure

Cold chain gaps significantly contribute to FLW:

- **Lack of on-farm cooling**: Smallholders and cooperatives often lack refrigerated facilities to store avocados post-harvest, accelerating ripening and spoilage.
- **Limited refrigerated transport**: Avocados are frequently transported in unrefrigerated vehicles, especially in rural areas, impacting freshness upon arrival at export facilities.

4.3 Long Transit Times and Limited Direct Shipping Routes

Kenya currently lacks direct shipping routes to the EU, resulting in extended transit times (35–40 days). Avocados are shipped indirectly, often via Salalah port in Oman, which increases both time and cost. Comparatively, Peru offers direct shipping routes to Europe, allowing their avocados to arrive fresher and at a lower cost per container.

4.4 Certification and Market Access Challenges

Many smallholders are not certified under GlobalGAP or similar standards, which limits access to EU markets. Certification requires training and compliance with EU quality standards, which can be challenging for smallholder farmers due to cost and logistical constraints.

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5. Recommendations

5.1 Enhancing Cold Chain Infrastructure

- **Investment in Cold Storage Facilities**: Establish regional cold storage facilities accessible to smallholder farmers, particularly in key production areas. These facilities could be operated by cooperatives or private-sector partners, ensuring smallholders have access to essential infrastructure.
- **Refrigerated Transport Systems**: Develop partnerships with logistics providers to offer subsidized refrigerated transport from farm to export hubs. Cold chain continuity can significantly reduce spoilage during transport to export facilities.

5.2 Establishing Direct Shipping Routes

- **Collaboration with Export and Shipping Sectors**: Lobby for a direct shipping route from Mombasa to Rotterdam, which would reduce transit times to approximately 20 days. This route could leverage Kenya's existing flower export routes, which similarly benefit from reduced transit times.
- **Cost-Benefit Analysis and Feasibility Studies**: Conduct studies to assess the economic viability of a direct route and identify potential partners, such as international trade agencies, willing to invest in this logistics upgrade.

5.3 Quality Control and Standardization at the Cooperative Level

- **Training Programs on Harvesting and Handling**: Cooperatives should implement training sessions on proper harvesting techniques, post-harvest handling, and storage methods to ensure avocados meet export quality standards.
- **Centralized Quality Aggregation Centers**: Establish quality aggregation centers that sort, grade, and package avocados according to EU specifications. Centralized facilities would allow cooperatives to standardize quality and ensure compliance with EU import standards.

5.4 Certification and Compliance Support for Smallholders

- **Subsidized Certification Programs**: Partner with certification agencies and government bodies to provide subsidized GlobalGAP certification programs. Certification will open access to high-value EU markets, thereby increasing potential revenue for smallholders.
- **Educational Workshops on EU Market Standards**: Conduct workshops for farmers on EU quality requirements, including acceptable pesticide levels, uniformity standards, and packaging guidelines, to align production with market expectations.

5.5 Data-Driven Supply Chain Management

- **Implementation of Digital Monitoring Tools**: Introduce digital tools for tracking temperature, transit times, and quality metrics throughout the supply chain. This will provide real-time data to monitor quality and predict ripening rates, enhancing decision-making.
- **Forecasting and Inventory Management Systems**: Importers and cooperatives can use demand forecasting tools to improve inventory management, thereby reducing the likelihood of over-ripening and waste due to overstocking.

6. Detailed Implementation Strategy

6.1 Collaborative Framework for Cold Chain Development

The implementation of cold chain facilities requires collaboration between stakeholders:

- **Public-Private Partnerships (PPPs)**: Government and private investors could co-fund cold storage facilities in major avocado production zones. In return, cooperatives could offer discounted rates to farmers, encouraging widespread usage.
- **Incentivizing Refrigerated Transport**: Tax incentives for logistics providers could encourage the introduction of refrigerated trucks in avocado-growing regions. Cooperatives can facilitate bulk transport arrangements to reduce costs per farmer.

6.2 Advocacy for Direct Shipping Routes

- **Stakeholder Advocacy Group**: Create a working group comprising government representatives, cooperatives, and exporters to negotiate with shipping companies for a direct route. Highlight Kenya's position as an emerging avocado and flower exporter to emphasize the route's viability.

- **Cost Reduction Initiatives**: To attract stakeholders, the government could reduce port fees or provide subsidies for exporters who use the direct route.

6.3 Enhancing Cooperative Capacity

- **Train-the-Trainer Programs**: Cooperatives could establish "train-the-trainer" programs, empowering local leaders to disseminate best practices for harvesting and handling avocados. This model ensures that training reaches remote areas and that knowledge is retained within communities.
- **Centralized Sorting and Packaging Facilities**: Co-located sorting and packaging facilities within cooperatives would ensure compliance with EU quality standards, reduce waste, and improve efficiencies in packaging.

6.4 Financial Support Mechanisms for Certification

- **Microfinance and Cooperative Loans**: Develop micro-loan programs with low-interest rates, accessible to smallholders seeking certification. Loans can be repaid through increased revenue gained from certified market access.
- **Government-Backed Subsidies for Certification**: Government partnerships with NGOs could help subsidize certification costs for farmers, promoting widespread compliance with export standards.

6.5 Integration of Technology and Data Management

- **Supply Chain Tracking**: Partner with agri-tech providers to offer tracking systems that monitor avocados from farm to port, providing stakeholders with actionable data to minimize FLW.
- **Inventory Management Software for Importers**: Digital tools can enable importers to monitor ripening timelines more effectively, allowing them to manage supply according to demand fluctuations and reduce unnecessary waste.

7. Monitoring and Evaluation

To ensure the effectiveness of these recommendations, establish a Monitoring and Evaluation (M&E) framework that includes:

- **Key Performance Indicators (KPIs)**:
    - Reduction in FLW from farm to export (measured as a percentage of total production).
    - Average transit time reduction through direct shipping routes.
    - Increase in certified smallholders accessing EU markets.
    - Quality consistency as measured by EU import compliance reports.

- **Regular Reporting**: Require cooperatives and exporters to submit periodic reports on quality, handling practices, and certification progress. This data will support ongoing improvements and provide insights for further refinement of practices.

8. Long-Term Impact and Conclusion

Optimizing Kenya's avocado supply chain presents an opportunity to enhance the nation's economic standing in the global avocado market. Implementing the recommended strategies will not only reduce FLW but also improve market access, profitability, and competitiveness. A more resilient supply chain, with integrated cold storage, direct shipping, and stringent quality controls, would position Kenya as a trusted supplier of high-quality avocados in the EU.

Kenyan stakeholders—ranging from farmers and cooperatives to government bodies—are encouraged to adopt a coordinated approach to realize the benefits of these recommendations. As these strategies are implemented, ongoing adjustments based on market trends and feedback will further ensure the long-term sustainability of the avocado supply chain.

Reducing the waste of fresh avocados from Kenya into the Netherlands by using the Iceberg model

Article

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Reducing the waste of fresh avocados from Kenya into the Netherlands by using the Iceberg model

Jianing Zhu

Practice Brief
FORQLAB Project 2023-06

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

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Introduction

Kenya is the eleventh-largest exporter in the world and the seventh-largest producer of avocados worldwide. For the Netherlands, Kenya is also an important main supplier country. In Kenya's avocado export market, approximately 15% of the avocado waste occurs between the farm and the consumer (Snel et al., 2021). However, the actual volume of market losses (both wholesale and retail) is significant but poorly understood (Snel et al., 2021). Companies that imported avocados from Kenya are interested in the potential of applied research to reduce waste and improve the quality of this part of the production chain. The objective of this research is to find out: What factors make fresh avocados imported from Kenya unconsumable in the supply chain part from wholesale to retail in the Netherlands?

Methodology

First, a literature review was conducted. Factors investigated in the literature were modified based on information provided by interviewees. Based on the findings of the literature, two online interviews were conducted with Dutch avocado wholesalers who imported Kenya avocados, as well as three face-to-face interviews with Delft supermarket managers. Inholland Yammer was used to conduct an online survey. The questionnaire was completed by 110 people in the role of consumer. The likelihood ratio for the chi-square test and Kendall's tau-b were used in IBM SPSS 26 to investigate the significance and extent of the impact (McHugh, 2013). The analysis employed a 95% confidence interval.

The iceberg model shows how observable events, underlying patterns, supporting structures, and mental models can be abstracted from a situation or organization (Trubetskaya, Scholten, & Corredig, 2022). By using an iceberg model, people can know which problems happened on which level.

The current situation of unconsumable fresh avocados

- 5~6% of imported avocados cannot be sold, with variations depending on season and country of origin. May, June, and July are typically months of global overproduction and oversupply.
- Very few avocados remain unsold on supermarket shelves according to supermarket managers. Only about 2% of the avocados delivered to supermarkets were deemed unsellable. However, wholesalers estimate that 10% to 15% of fresh avocados in supermarkets went unsold and became inedible.
- Supermarkets send avocados with external damage but intact interiors to food banks.
- Wholesalers send avocados that can’t be sold as fresh fruit to other industries, such as avocado oil production.

The patterns leading to (unconsumed) fresh avocados

On the pattern level, it involves identifying patterns, trends, or recurring themes that emerge from the surface-level observations. It requires a deeper analysis to recognize the connections and regularities.

- Oversupply: Wholesalers import too much during certain seasons. The surplus caused storage facility shortages, preventing avocados from being stored at optimal low temperatures before ripening. Handling large volumes quickly increased human error. Sorting, packing, and storing errors can occur under pressure to process and distribute avocados efficiently. Errors increase avocado waste.
- Internal & external damage: Low transportation temperatures or nutrient deficiencies can darken or gray the avocado's interior. Retailers return avocados for poor quality, often due to internal diseases that were undetectable by machines and developed during transport. Most of the store's waste is caused by a delivery issue that bruised avocados, making them unsellable.
- Failed to ripe: Fresh avocados with a dry matter content lower than 21% are likely to fail in ripening. Within the avocados placed in ripening facilities, approximately 5% are wasted due to variations in ripening rates, with overripe avocados rendering them unsuitable for consumption.
- Wasted as samples: A minimal proportion of imported avocados (less than 0.1%) remain unconsumed because of rigorous quality inspections for firmness and dry matter.
- Late delivery: Delayed avocado deliveries may be rejected by retailers, and during the time to return them to the warehouse, avocados may be ripe, making them unsuitable for sale. Logistics waste accounts for 2%–3% of avocado waste.
- Improper organizing: Improper organizing can contribute to human errors, such as incorrect labeling and packaging, which in turn can lead to higher return rates.
- Improper display: Consumers don't always pick avocados underneath the shelf. In the supermarket, if the avocados underneath were not well-arranged or appear less fresh compared to the ones on top, customers may perceive them as less appealing and choose avocados from the upper layers instead.
- Wrong storage condition: The best storage conditions for fresh avocados, especially for ready-to-eat avocados, should be in refrigerators, while most of supermarkets only put them under room temperature.

The structural factor behind (unconsumed) fresh avocados imported from Kenya in the supply chain from wholesale to retail in the Netherlands

At the structural level, the emphasis switches to the underlying systems, structures, or processes that underlie the patterns and trends that are visible.

- Overwhelmed management: Important tasks may be neglected, leading to problems such as quality issues and an increase in human errors, which also influences the communication between different parts of the supply chain. Especially during oversupply periods.
- Inefficient logistics and planning: Avocado production outpaces demand growth, leading to unsold inventory and reduced profitability.
- Imbalanced supply &demanding: Avocado production had increased by 15% to 20%, while the demand in Europe had only risen by 5% to 8%. Growers sold lots of avocados due to high farming costs. To balance supply-demand, wholesalers offered promotions to boost sales. To avoid unsold inventory and maintain profit margins, retailers avoided accepting excessive avocados. Due to supply outstripping demand, the avocado supply chain struggled. Growers and wholesalers suffered financial losses when avocados were spoiled. Growers also struggled to get stable returns on their investments due to supply-demand dynamics.
- Lack of communication: Growers desire to maximize profit caused wholesaler-grower conflict. These issues caused inaccurate inventory forecasts, but they were fixable. Supply-and-demand control depended on retailers. Postponing orders while searching for new customers could help wholesalers manage excess stock. Improved retailer-wholesaler communication helped ripening processes. Adjusting the ripening process based on consumer demand improved avocado quality, shelf life, and spoilage.
- Preference for RTE: Approximately 40% of all avocados were categorized as ready-to-eat (RTE).

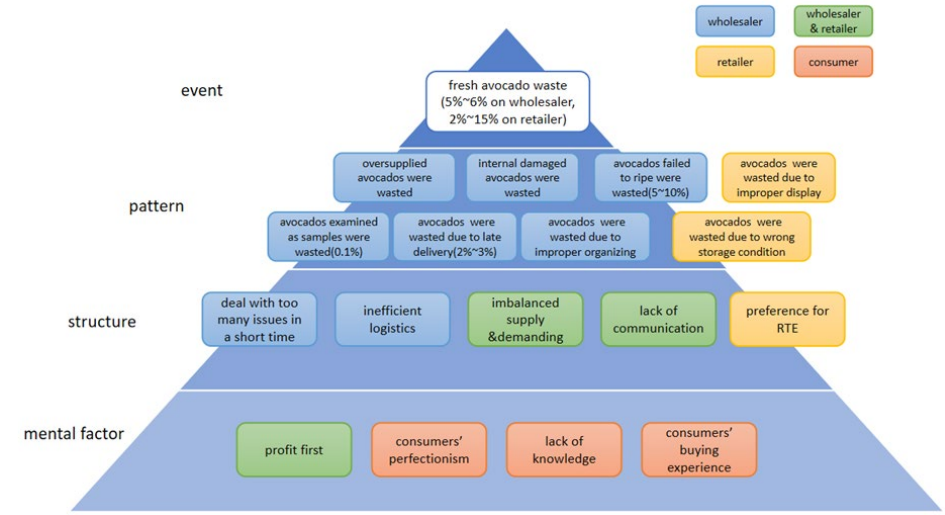
RTE avocados have a shorter shelf life compared to unripe avocados. Also, RTE avocados require higher proficiency in ripening techniques, making it more prone to failures when ripening them to the desired ready-to-eat maturity, thus resulting in more wastage.

The mental factor of (unconsumed) fresh avocados imported from Kenya in the supply chain from wholesale to retail in the Netherlands

Mental factors refer to the conscious or subconscious assumptions, beliefs, and values that individuals hold about a system (Maani & Cavana, 2007).

- Profit first: Both wholesalers and retailers frequently put short-term financial success and inventory control ahead of thinking about the long-term effects of waste and its effects on the environment and society. The profit-first mentality prioritized profit and on-shelf availability over waste reduction and sustainability. Wholesalers and retailers stocked more products, even if they expired or were not sold, to ensure availability.
- Consumers' perfectionism: Even with a taste guarantee, avocado buyers who value appearance are less likely to buy subpar avocados. Despite knowing the best-before and used-by dates, people who prefer good-looking avocados are unlikely to buy sub-optimal ones. However, if a guarantee is offered, consumers who think appearance is somewhat important will buy sub-optimal avocados. Respondents who do not prioritize avocado appearance as very or somewhat important are more likely to "Be sure to buy it" when a quality guarantee is provided. Those who don't care about appearance don't seem to care about buying.
- Lack of knowledge: People familiar with best-before and used-by dates were more likely to buy sub-optimal avocados in the past. Those unaware of these dates are less likely to buy. Knowing the best-before date increases the likelihood of buying suboptimal avocados.
- Consumer's buying experience: Individuals who buy avocados more frequently are more likely to have purchased avocados in sub-optimal conditions. If more than 35% discount can be provided for sub-optimal avocados consumers are more willing to buy them. Avocado promotions influenced consumer purchases, according to wholesaler interviews. Promotion timing also mattered. When they got paid, consumers bought avocados more often. At the end of the month, consumers may have had less disposable income, making promotions less profitable.

Picture 1 depicted the conceptual model of fresh avocado waste, presenting a visual summary of the research findings. The model represents various stages of the avocado supply chain. The blue boxes indicate instances of waste occurring at the wholesale level (including the importers), while the yellow boxes represent waste occurring at the retail level. The green boxes indicate waste occurring at both the wholesale and retail levels, while the red boxes signify waste resulting from consumers' behaviour.



Picture 1 Avocado waste iceberg model

Conclusions

Structural and mental factors are the main factors that make fresh avocados imported from Kenya unconsumable in the supply chain from wholesale to retail in the Netherlands.

- Unsold inventory and waste in the avocado industry on structural level have resulted from unbalanced supply and demand dynamics, as well as inefficient logistics practices. Avocado production has grown faster than demand, contributing to the problem.
- Delays in container deliveries have caused avocados to ripen in transit, exacerbating the problem.
- Inadequate communication throughout the supply chain has hampered inventory forecasting and ripening process coordination.

For mental factors,

- The profit-first mentality of the industry has prioritized short-term financial success and inventory control over waste reduction and sustainability.
- Consumer behaviour has also contributed to waste, as evidenced by a focus on avocado appearance and perfectionism, and a reluctance to accept suboptimal avocados.
- A lack of knowledge about best-before and used-by dates.
- The amount of waste generated has also been influenced by factors such as the consumer purchasing experience and the frequency of avocado purchases.

Using Porter's value chain, Picture 2 demonstrated where wastes occur in wholesaler organisation, Picture 3 demonstrated where wastes occur in retailer organisation, as well as partially displaying the amount of waste at various positions. By checking each stage of the value chain, these images provide a comprehensive understanding of where waste occurs and offer insights into the magnitude of waste at various positions.

Wholesaler	Inbound logistics	Production/operations	Outbound logistics	Marketing and sales	Customer services
Primary activities	• purchasing fresh avocados form Kenya • checking the samples • sending avocados to ripening facility	• quality check • grading • ripening • packaging	• sending fresh avocados to buyers • managing warehouses • organizing transportation logistics • coordinating with retailers	promoting and selling avocados to potential buyers. The wholesaler may engage in marketing activities such as advertising	• offering prompt support • handling customer inquiries and complaints • providing information on avocado quality, availability, and pricing
Wastes	• oversupplied avocados were wasted • avocados examined as samples were wasted	• internal damaged avocados were wasted • avocados failed to ripe were wasted(5~10%) • avocados were wasted due to wrong packaging(minimal waste)	• avocados were wasted due to late delivery(2%~3%)		

Picture 2 Porter value chain for wholesalers

Retailer	Inbound logistics	Production/operations	Outbound logistics	Marketing and sales	Customer services
Primary activities	• purchasing avocados from wholesalers • sending avocados to their supermarkets	• quality check • putting avocados on the shelf • checking the inventory level	• distributing avocados to customers • managing inventory levels • ensuring timely restocking of avocados	• advertising, creating attractive displays, and running promotions or discounts to encourage avocado sales	• assisting customers in finding avocados • answering their queries • addressing any concerns or complaints
Wastes	• avocados were wasted due to late delivery(2%~3%)	• avocados were wasted due to wrong storage condition		• stalled avocados were wasted(2~15%)	

Picture 3 Porter value chain for retailers

Recommendations

Wholesalers and retailers should work together to improve avocado supply chain communication, supply and demand, and waste. The industry aims to optimize avocado distribution and supply high-quality avocados by improving communication, aligning supply with demand, and educating consumers. These steps will reduce waste and improve avocado production.

For further research, surveys should include students and other demographics. Interviewing supermarket managers from various Dutch regions would yield valuable insights that could be applied to a larger population. The results would be more representative and applicable if more people participated. Retailers should investigate Direct Profit Profitability and the contractual relationship between growers, wholesalers, and retailers.

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Introduce Kenyan Frozen Avocado to the Netherlands

Article

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Introduce Kenya Frozen Avocado to the Netherlands

Xiaoyi Zhang

Introduction

The general export season for Kenya is from April to September. It will compete with Peru, South Africa, Israel, Mexico, and Spain. These competitors all have good reputation on quality (CBI, 2022). However, the production is dominated by small-scale farmers. It contributes to the challenge of quality and certificates for export (Snel et al., 2021). Also, the production of avocados is seasonal. The two aspects (small-scale farmers and seasonal) result in the low value for the chain of avocados and 10%-20% of avocados will be wasted (CBI, 2022; Kiilu & Wambugu, 2001; Snel et al., 2021). Individual Quick Freezing (IQF) in Kenya is considering as an approach to solve the short shelf life of perishable fruits and help supply products all year round (Sebastian, 2020). The Netherlands is the center of import and re-sell frozen fruit products in the Europe market (CBI, 2020a). As estimated, 70% of the frozen products will go to food processing industry and there is a great increasing in food service industry in Europe (CBI, 2020b). Also, the trend of seeking convenient and healthier alternatives provide a potential consumer market for frozen fruits (CBI, 2020b). Therefore, the objective of the project is to investigate the opportunities to sell IQF frozen from Kenya to the Dutch market to reduce oversupply food waste by doing literature study, interviews, and market survey.

Methodology

The research included two parts: interviews and market survey.

Interviews: Sunripe was selected as the Kenya IQF avocado exporter and processor to understand their capacity and processing status. For B2B market (Dutch importer/food processor/food services), the questions were about the competitors in the market and their preferences. The collected data were analysed by SWOT matrix and Porter's 5 Forces. The former was used to indicate the strengths and weaknesses of Kenya IQF avocados, and the opportunities and threats of the Dutch market; the latter was used to know the competition in the Dutch market.

Market Survey: The target group of the market survey is Dutch consumers. For questions "satisfaction of the frozen avocado in the Dutch market" and "willingness to buy frozen avocado instead of the fresh for different factors", the two questions are the scale questions. The quantitative data will be defined with number (e.g., Very Satisfied-5, Very Dissatisfied-1). It will be

presented as the average score first. For each score, it will be compared to the score that is lower than itself by One-sample t test to show if it is significantly different with the lower score ($p<0.05$). Also, since the data is categorical data, it will be analysed with Chi-square by SPSS ($\alpha = 0.05$) to check whether the factor will affect their choice. For the rest questions, the results will be analysed by frequency and make it visible by bar chart or pie chart.

Current Situation of Kenya IQF Avocados

Strengths:

- Both in the literature study and survey, IQF avocado can help extend the shelf life of fresh avocados and supply all year round. Therefore, it means a better profit.
- Kenya government will set up frequent bans on the fresh avocado exports to ensure their quality. Sunripe claimed that the IQF can help solve the problem of perishability and break the bans of the fresh avocado, which extends the Kenya avocado supply period, creates more profits, and reduce the food waste.
- Regarding the quality of frozen avocados, IQF can provide almost the same texture/flavour products as the fresh.

Weaknesses:

Generally, the Kenya frozen avocado industry is facing these challenges (Kiilu et al., 2001):

- Lack of international and regional standards and product specifications
- Availability of raw materials (fresh avocados)
- Lack of storage facilities
- High requirements of processing facilities during peak season and low utilization in the rest time

However, as the pioneer of the Kenya IQF avocados, Sunripe does not face these challenges. They have international food certification (e.g., Global G.A.P). Also, their avocado trees can fruit 9 months a year. These fruits can be processed immediately after being picked and kept under Controlled Atmosphere (CA) after being processed, they can ensure the continuity of the cold chain as well. Regarding the utilization of the machines, they have other frozen products to process (e.g., broccoli). The situation will be different due to the size of the company.

- For Sunripe, they will add antioxidants to ensure the quality of products.

Competition of Kenya IQF Avocados in Dutch Market

Threats of New Entrants:

Vietnam shows an increase in export to Europe to be a potential competitor (CBI, 2020b). It may be a sign for the easier entry of new entrants. Also, the Netherlands is one of the biggest European frozen fruit markets, which is also the largest importer and re-exporter in Europe (CBI, 2020b). The threats will be *high*.

Bargaining Power of Suppliers:

As for the suppliers, in the literature study, the main frozen avocado supply countries for European market are Vietnam, Mexico, and Peru (CBI, 2020b). There are many international companies in the market, such as Champion Food (Mexico). Also, there are many European companies, such as Salud Foodgroup (the Netherlands) and Syros (Belgium). These companies

have the same target market as Sunripe. Therefore, the bargaining power of suppliers is *low*.

Bargaining Power of Buyers:

In the market survey, only 39.8% of them have tried frozen avocados. For these consumers, the main reason for not choosing frozen avocados are "Quality Concern" and "Lack of Awareness of Products".

Threats of New Substitutes:

There are two types of substitutes: other type of frozen avocados, and fresh avocados.

a) Frozen avocados:

In the market survey, the satisfaction of three elements is 3.19, 3.21, and 3.10. The customers' satisfaction of frozen avocados in the Dutch market is on the Neutral level but not Satisfied.

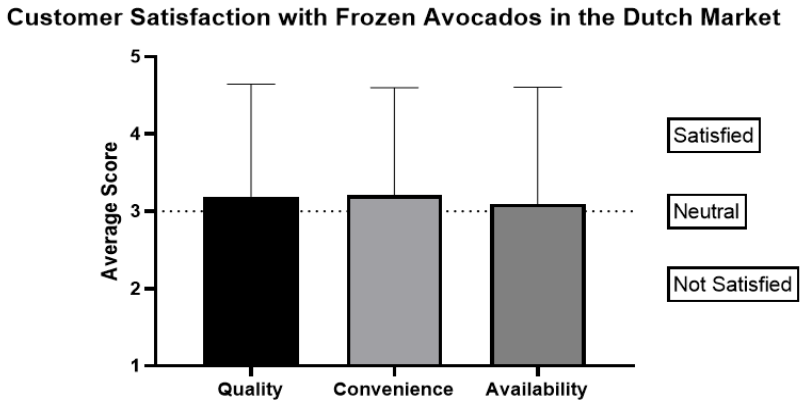

Fig. 1 Customer Satisfaction with Frozen Avocados in the Dutch Market (1-Very Dissatisfied, 5-Very Satisfied)

b) Fresh avocados:

In the market survey, consumers' willingness to buy frozen avocado rather than fresh avocado for four elements is 1.485, 2.153, 1.785, and 1.583. They are less willing to buy frozen avocados instead of the fresh with price, quality, and reputation. But they would like to buy the frozen for convenience.

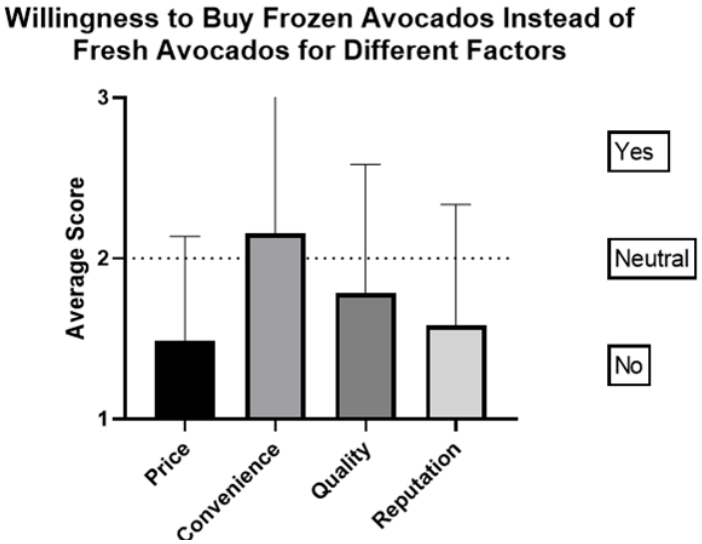

Fig. 2 Willingness to Buy Frozen Avocados Instead of Fresh Avocados for Different Factors

(1-No, 2-Maybe, 3-Yes)

Based on two figures, threat of other frozen avocados is *medium* since consumers are not enough satisfied with the products in the market; but the threat of fresh avocados is *high*, because they are less interested in the frozen avocados with "Price" "Quality" and "Reputation" when compared to the fresh. Therefore, the threat of substitutes is *high*.

Competition in the Industry:

Based on the information above, Kenya IQF avocados have to face the competition from Mexico, Peru, Vietnam, and even the European competitors. Regardless of them, Kenya IQF avocados also need to join the race with fresh avocados. Therefore, the competition in the industry is *High*.

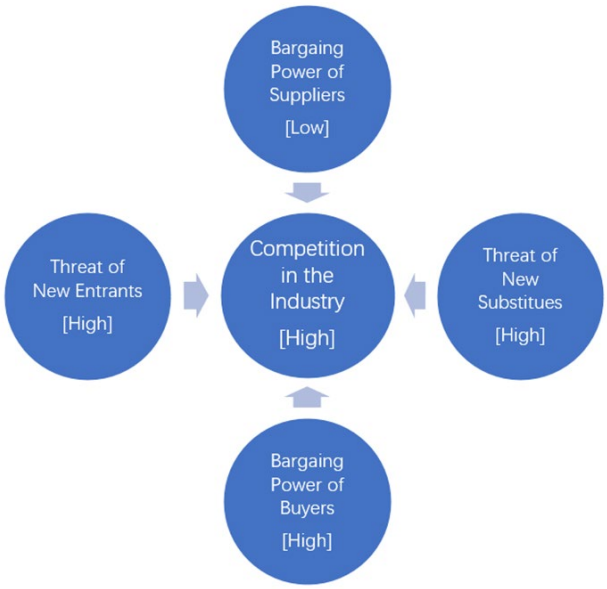

Fig. 3 Porter's 5 Forces, described the competition that Kenya IQF avocados will face in the Dutch market.

EU Regulations on Frozen Avocados

There are two aspects of EU regulations that related to frozen fruits.

Control of contaminants:

- Pesticide Residue
- Microbiological Contaminants
- Heavy Metals

These three are the main perspectives of contaminants. For Pesticide, importers are responsible for checking and testing. The unqualified products will quit the market. Also, European Union also has official border controls for pesticides. The requirements will be stricter if the products are repeatedly non-compliant (CBI, 2020b; Regulation (EU) 2022/913). The common microbiological organisms in tropical fruits are norovirus and salmonella. And this is related to the production environment and post-harvest. Regarding heavy metals, according to the European Commission Regulation (EC) No 1881/2006, lead and cadmium may be present in frozen fruits, which are possible from the cultivation environment, packaging materials, etc.

Temperature Control: For IQF products, EU has special requirements for them. Due to the special product characteristics, the temperature should be equal and even lower than -18 ℃ on every step of the chain to guarantee the quality (CBI, 2020b).

Buyers Requirements on Frozen Fruits

B2B:

The general requirements are about four aspects:

- Quality: According to the research from CBI (2020b), as an element of the quality, taste will be influenced by additives. Additionally, a good quality IQF products should be individual with each other (CBI, 2020b; Shahnawaz & Shiekh, 2011).
- Certificates: Popular certificates are International Featured Standards (IFS), British Retail Consortium Global Standards (BRCGS), Food Safety System Certification (FSSC 22000), Global G.A.P and HACCP (Arana Coronado et al., 2015; CBI, 2020b; Match Maker Associates, 2022).
- Traceability: Considering the food safety for consumers, many stakeholders require the traceability of the products, so that they can recall the faulty products. Also, consumers prefer to know the footprint of the whole journey of the product from the farm to the shelf (CBI, 2020b).
- CSR: Some pioneers have designed the common rules and prefer their suppliers to follow their rules of CSR and CSRD (directive), but the requirements could be diverse (CBI, 2020b).

B2C:

- Quality: Consumers prefer to have products with less and even no additives/ preservatives. Also, the texture/taste should be as same as the fresh. The product should be sustainable as well.
- Convenience: Consumers are seeking healthier and convenience food. They prefer the product can have longer shelf life and save time. But they didn't show a strong interest in the characteristics of IQF avocados: freezing individually.
- Price: Price is not the key element that affect their choices. Some consumers worry that a lower price means a worse quality.
- Origin of Suppliers: Consumers don't care about the origin of suppliers much.

Both in the literature study and market survey, consumers showed a strong willingness to buy frozen avocados for special foods (e.g., smoothies). It also affects potential consumers' choice for trying frozen avocados in the future: people who buy frozen fruits for special foods will be more willing to try frozen avocados (Table 1).

Table 1. Chi-square Analysis of "Specific Food" and "Willingness to try frozen avocado in the future" ($p<0.05$).

		Willingness to try frozen avocado in the future			Total	X^2	*p*
		Yes	Maybe	No			
Buy frozen fruits to make special food (e.g., smoothies)	Yes	13	14	7	34	8.253	0.016
	No	10	12	24	46		
Total		23	26	31	80		

Therefore, the opportunity and threats in the Dutch market can be summarized.

Opportunity:

- Consumers are seeking convenience and healthier alternatives (smoothies). People who buy frozen fruits for special foods are more willing to try frozen avocados in the future.
- People are looking for avocado products with a longer shelf life.
- People in the Dutch market not that care about the origin of the suppliers.

Threats:

- People are not that interested in "freezing individually".
- Customers prefer to have less additives/ preservatives.
- The awareness of the frozen avocado is limited.
- Due to the concerning of quality, people prefer to have fresh avocados.

To have a better overview of Kenya IQF avocados, SWOT is selected to know all aspects of the internal and external conditions of it will be integrated and summarized.

Strength	Weakness
1. IQF can produce almost the same texture/ flavor products as the fresh. 2. Compared with the fresh avocados, the IQF avocados can have longer shelf life and supply all year round. 3. IQF avocados can help breaks the frequent bans on fresh avocado export in Kenya. 4. Big companies (such as Sunripe) are able to ensure the quality of the products and meet the requirements of the customers (availability, certificates, sustainability, and traceability).	1. The abilities to meet the requirements of Dutch market depend on the company size. 2. It's difficult to have certificates and be a part of the supply chain for small-scale farmers. 3. The products will be added with antioxidants.
Opportunity	**Threat**
1. The trends of seeking convenience and healthier alternatives (smoothies) help expand the market. 2. People are looking for avocado products with a longer shelf life. 3. People's satisfaction of the frozen avocado products in the Dutch market is Neutral. 4. People in the Dutch market not that care about the origin of the suppliers.	1. People are not that interested in "freezing individually". 2. The competition in the Dutch market is intensive. 3. Customers prefer to have less additives/ preservatives. 4. The awareness of the frozen avocado is limited. 5. Due to the concerning of quality, people prefer to have fresh avocado 6. B2B market prefer their suppliers are able to have traceability of their products. 7. Consumers prefer to buy sustainable products.

Fig.4 SWOT Matrix, provided the internal and external conditions of Kenya IQF avocados. Strength and Weakness are about the internal analysis of Kenya IQF avocados; Opportunity and Threat are about the external analysis of Dutch market.

Conclusion

The quality of Kenya IQF avocados can be different for the size of the company. Bigger company can be easier to meet the requirements of Dutch market.

In term of the quality of IQF and none IQF avocados in the Dutch market, consumers are not enough satisfied with them. Also, they prefer to buy fresh avocados instead of the frozen due to a better quality.

Regarding the requirements, EU regulations have legislated the restriction on Control of contaminants and temperature control of the products. Therefore, Kenya IQF avocados should take care of the environment of the production area and ensure the continuity of the cold chain.
For B2B market, companies have their own preferences on quality, certificates, traceability, and CSR. However, due to the limitations of the survey, the detailed information is still unknown, which could be the direction of the further study.
Regarding B2C market, consumers showed that "Quality" and "Convenience" are the top elements that affect their choices. For quality, they hope the products can have almost same texture as the fresh, and with less additives/preservatives. Also, the product will be better if it's sustainable. For convenience, they prefer the products can have longer shelf life and save time.
Overall, Kenya IQF avocado can be successful to enter the Dutch market, but it may be not suitable for all companies. For big companies, the trend of smoothies, seeking convenience food, and preferences on sustainability are the opportunities for them to enter the Dutch market.

Recommendations

- Big Kenya IQF avocado producers/exporters should cater to the growing trend of seeking convenient and healthier alternatives (e.g., avocado smoothies) with their products by producing high-quality product with almost the same texture and flavour as fresh avocados.
- Small companies can collaborate with big companies and make use of their expertise and resources to overcome the challenge of meeting the requirements of the Dutch market based on company size.
- Differentiate from competitors by emphasizing the superior quality and assurance provided by big companies like Sunripe, reassuring customers about the product's trustworthiness.
- Bigger companies should enlarge their influence to help the farmers learn more knowledge of growing high-quality avocados.
- The government should provide support and guidance for small-scale farmers. Educate them with cultivation knowledge and help them reduce the usage of chemicals.
- The industry should look for approaches to reduce or eliminate the use of antioxidants in the IQF avocado to meet the customer preferences.

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Introduction and methodology

In the report, a business and implementation plan is written for container transport of avocados. To be able to answer the main question: ***" How can the FORQLAB project effectively establish and implement a sea freight container transportation service to export avocados from Kenya to the Netherlands? "***.

FORQLAB (Food Waste Reduction and Food Quality Living Lab) is a project started in 2022 and ending in 2024, which is a multi-year research project to structurally reduce food losses and improve food quality in Kenyan avocado and dairy chains. The project links producers in Kenya with Dutch importers (avocados) or local businesses (dairy). The research takes place in two areas in Kenya for both avocado and dairy; a relatively well-developed chain in the central highlands and a less-developed chain in western Kenya. The applied research will be carried out by several universities involved, two in Kenya and four in the Netherlands.

To carry out this research, the following research methods have been used: literature study, internal source research, in-depth interviews, group discussion & observations. The information that comes out of this is mainly qualitative data. After concluding the project, the acquired results are given back to the FORQLAB project. Also, the opinions of all stakeholders are important and have been taken into account. Using the above research methods, the main question is answered.

Market

Over the past ten years, the production and commerce of avocados have grown rapidly worldwide, also in Kenya. The avocado trade will expand over the coming years, but as the market becomes more competitive, producers will need to become more efficient and sustainable. For Kenyan avocados, there is global competition with mainly Mexico, Peru, and Colombia to supply the European market. Therefore, it is important that Kenyan avocados are of high quality.

The market for avocado exports from Kenya is expected to continue growing in the coming years, driven by increasing global demand for fruit, particularly in Europe and Asia. Kenya is one of the

leading producers of avocados in Africa, and the country has been investing in improving the quality and quantity of its avocado production to meet international standards. As production rises, exports of avocados from Kenya to countries such as the United Arab Emirates, Saudi Arabia, China, and the European Union have also risen. (Figure 1)

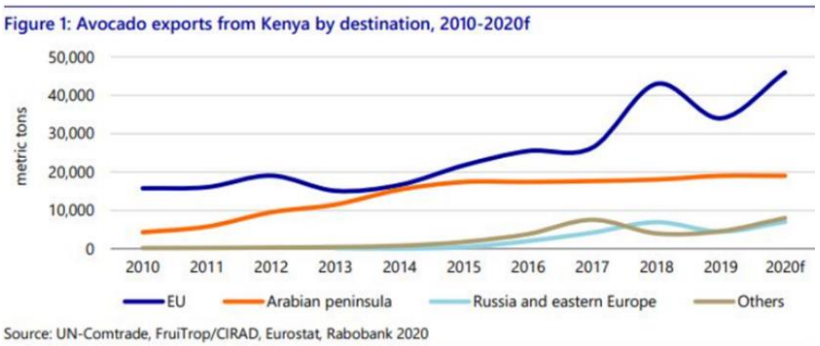


Figure 1, Kenyan avocado export and destination, retrieved from, https://research.rabobank.com/far/en/sectors/fresh-produce/kenya-avocado-sector-growing-fast-but-still-growing-up.html

Challenges:

There are a few challenges for the export market of avocados. The first one is infrastructure. The poor quality of the roads from the farmers to the port can cause the quality of avocados to deteriorate. This is due to potholes and bumpy roads, which also prevent refrigerated trucks from entering some roads, which affects the quality of avocados.

The second one is shipping conditions. Avocados are fruits and are sensitive to ethylene. Therefore, it is difficult to combine them with other ethylene-emitting perishables (fruits, vegetables, cut flowers) in the containers. Only later in the season when the avocados are more mature, they can be combined in containers with ethylene blockers.

Another challenge is political issues and working together with the Kenyan government. They do not have any knowledge about avocados, such as the different types of varieties. Also, the government makes it obligatory to scan every outgoing container. This can be quite frustrating as most scanners are not functioning and it takes a lot of unnecessary time. Added to this are the forms and documents required to transport avocados.

The last challenge is international, fast-rising demand & supply. The demand in Europe for avocados keeps growing. So many countries just like Kenya are planting immense amounts of avocado trees. Therefore, there is going to be a turning point when the supply is going to explode. When this happens, a sustainable quality product will be the minimum, and parties involved in the supply chain need to prepare for this.

Competitors:

If a cooperative from FORQLAB will be specializing in the export of avocados, the most relevant competitors can vary depending on factors such as geographical location, target markets, and specific services offered. Kenya currently has five major exporters of avocados, namely: Keitt, Kakuzi, Selina Wamucii, Mt Kenya Fresh avocados, and Sasini. Currently, Nandi cooperative, among others, is working with Keitt. To export to the Netherlands itself, more financial resources and an outlet market are currently needed.

Logistics

The ideal supply chain for the transportation of avocados by sea is quick and efficient, because of the long transport time. In practice, this means that the products are harvested, sorted, graded, and packaged in the same area while maintaining the cold chain. The containers are loaded and transported to Mombasa where they are shipped to the Netherlands.

Duration

The transport to the Netherlands by boat takes anywhere from 21 to 35 days, depending on the shipping line, shipping route, and other circumstances. Shipping to other European destinations like Genoa and Valencia is faster, but the costs are roughly the same, and the circumstances are less ideal because the containers are opened before the products are transported by truck to the desired destination. At the moment there are four companies that arrange transport by sea for reefers: Maersk, MSC, CMA, and Messina.

Best option sea freight routes

shipping line	destination	trans shipping	travel days			remarks
			ideal schedule	realistic schedule	disaster schedule	
CMA	Rotterdam	Jeddah	28	35	35	• Weekly sailing to Rotterdam • Frequently miss connections or have blank sailings • Mombasa port is the cause of some delays
	Marseille	Jeddah	25	32	32	
	Genoa	Jeddah	22	29	29	
Maersk	Rotterdam	Salalah & Algeciras	24*	31	38	• Weekly sailing • Dedicated berth in Mombasa for Maersk
	London Gateway	Salalah	28-29*	35	42	
MSC	Rotterdam	King Abdullah Port	24-28	31-35	42	• Not weekly sailing
Messina	Genoa	Direct	21	21	31	A sailing every 10 days

Figure 2 Sea freight routes. Embassy of the Netherlands. (2021). A study on sea freight for Kenya's agricultural exports. May.

Technical requirements

For the Kenyan 'Hass' avocado, the temperature during transport should be between five °C and seven for the early season fruit and four °C to five and a half °C for late season fruit. The optimum humidity is around 90-95 percent RH, Relative humidity. Also, ventilation has to be used to remove CO2 that is produced by the respiration of the avocados. If the avocados are transported by containers that have this possibility, the oxygen level should be set up between two percent and five percent. The Carbon dioxide is between three percent and ten percent. Those circumstances are important throughout the whole supply chain, not only during the voyage, and can be achieved by using Controlled Atmosphere reefers. The containers are constantly monitored and settings can be adjusted remotely. A critical point is when the container is transhipped and runs out of power. Care should be taken to ensure that the cut-off time is as short as possible.

Marketing

Customers

To transport containers, supplying growers are needed. There are several cooperatives working with the FORQLAB project. These are currently already working with various parties like Keitt exporters. However, they want to make a big growth in the next two to three years. This is because the cooperatives have the future dream of managing the entire chain. As this is not yet possible financially, an interim solution needs to be found in the form of collaborations. This means there may be opportunities for a partnership between companies and cooperatives. One of the best ways to acquire new customers would be to seek partnerships and collaborations with local avocado farmers, cooperatives, exporters, and importers.

Added value sustainability

Sustainability is becoming a very important driver in global supply chains. All stakeholders in the chain are becoming more aware and conscious of the choices they make regarding the consumption of food commodities. Customers (in the Netherlands) are starting to become aware of the negative impacts which come along with the consumption of air freight imported products. This has escalated to the point where several Dutch supermarkets are no longer offering air freight transported fruits and vegetables in their stores. Furthermore, the European Union has set a goal to become carbon neutral before 2050. This means an economy without the emission of greenhouse gases. Also, the European Due Diligence law drives companies to report on their sustainability and take responsibility for every stakeholder involved in the supply chain.

Requirements

In order to be able to transport containers, supplies are needed. In the first stages of setting up container transport, no additional equipment is needed. In a later stage cold rooms and technical equipment are needed to form a consolidation center. Additionally, more personnel is needed for sea freight operations. Sea freight transport from Kenya to the Netherlands involves various operational and external risks, such as quality control, insurance, documentation, infrastructure, geo-political stability, etc.

Legal matters

Because the avocado is sold to the European market, it must meet certain requirements. Only class 1 avocados are accepted for import into the European market. Therefore, growers, exporters, and importers must comply with various certificates and documents regarding food safety, phytosanitary regulations, customs, quality standards, and authorities (figure 3).

Figure 3 certification process - from, https://intracen.org/media/file/6478

Avocados imported into the European Union customs territory must be accompanied by a summary declaration, which is presented to the customs authorities of the place where they are to be unloaded. Goods are then placed under a temporary storage situation not exceeding 90 days in any case, which means that they are stored under customs supervision until they are placed under any of the following customs procedures or re-exported.

Implementation

For the implementation and safeguarding of the business plan, a plan has been made on the basis of eight steps. A timeline has been developed starting with creating urgency and ending with a functional transport service and consolidation center for the exportation of avocados. This makes it possible to visualize the change for a company working with FORQLAB (Table 1). Every step can be

checked if it is still viable for the company and finally, it shows how it can be applied to the entire organization so that it can be guaranteed in the future.

Table 1 Change process timeline

Short term: < 3 months			
Communicate the changes to office and operations department.	Determine dependencies	Form a leading team, with the marketing and operation manager, to appoint who is responsible for the communication in their team.	Designate a FORQLAB member with the responsibility of monitoring the implementation.
Communicate the vision and key milestones of sea freight by explaining the reasoning.	Plan evaluation moment between the leading team every two weeks.	Plan monthly evaluations for the shareholders.	Communicate the timeline to the shareholders.
The marketing team develops a plan to attract customers.	Operation departments contact shipping lines for planning, pricing, etc..		
Medium term: 3 – 6 months			
Evaluation of the past three months, with the leading team and making adjustments along the way.	Trails for quality and variety.	Trials for sea freight with different shipping lines, domestic transport routes and exporters.	Continuing improvements and adjustments where needed.
Estimated milestone duration for the stakeholders.			
Long term: > 6 months			
Evaluate the financial situation and the viability of operations.	Yearly evaluation.	Evaluate if set goals are achieved.	Looking back on last six months. What could be better and what are the future goals.

Conclusion and recommendations

Several recommendations have been given for the FORQLAB project, the business plan for the sea freight container transportation of avocados from Kenya to the Netherlands. The recommendations are divided into three time periods; short, medium, and long-term. The main (four) recommendations include;

- Shift to Sea Freight: Kenya should invest in developing infrastructure and equipment for a (partial) shift from airfreight to sea freight. This recommendation is supported by the increasing demand for sea freight in the European Union market and the need for optimal conditions to prevent perishability during transportation.
- Focus on Sustainable Practices: FORQLAB should prioritize sustainability throughout its supply chain to meet the growing demand for sustainable options. This includes reducing carbon emissions by shifting to sea freight, investing in fuel-efficient trucks, exploring technical innovations, and partnering with sustainable shipping companies. Additionally, FORQLAB can cater to the niche market for sustainable avocados by offering tailored export services and addressing sustainability concerns.
- Comply with Import and Export Regulations: FORQLAB must ensure compliance with the import and export regulations set by the European Union and other relevant authorities. This includes meeting maximum residue levels for pesticides and contaminants, adhering to phytosanitary regulations, fulfilling quality standards, and following proper import procedures and customs declarations. complying with these regulations will ensure a smooth and lawful importation and exportation process.

Sustainable Sourcing

Development of Traceability in the Kenyan avocado value chain for small- and medium scale farmers

Extensive Summary
FORQLAB project 2023

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Dafa Witoelar, Sander Duijghuisen, Bertken de Leede (project leader)

HAS green academy

Introduction

In Kenya, avocados constitute a significant part of the country's agricultural exports. Even though the avocado plantations thrive, many small-scale producers still face difficulties adhering to strict procedures. These challenges range from consistently producing quality avocados, navigating through financial hurdles, to encountering numerous obstacles in forming robust relationships within the supply chain. This report aims to dig deep into these challenges and identify potential interventions that could improve traceability and transparency within the Kenyan avocado supply chain.

The focus of this project resides in enhancing traceability within the supply chain. Traceability serves as a crucial cornerstone in the path towards a sustainable supply chain, as it offers a comprehensive view of the product journey, from the farm to the final consumer. A well-implemented traceability system can ensure quality, prevent fraud, reduce waste, and ultimately, instil confidence among stakeholders, contributing significantly to the overarching goal of achieving a sustainable supply chain. Thus, it is the reason why this project places significant emphasis on traceability, recognizing its fundamental importance in carving a sustainable and prosperous path forward for Kenya's avocado supply chain.

The research question defined for this project is: How can the sustainable sourcing of avocados from Kenyan small- and medium-scale farmers be enhanced through interventions that improve traceability and transparency? To address this question, the research is organized into a multi-level perspective including three levels: landscape, regime, and niche.

Methodologies

The Multi-Level Perspective (MLP) is a tool used to understand how changes happen at different levels in complex systems like supply chains. It shows how various stages, stakeholders, and societal elements influence each other. The MLP splits the system into three parts: landscape, regime, and niche. The landscape looks at the big picture - global events and demands that shape the system. The regime represents the established rules and practices within the supply chain. The niche explores smaller, experimental areas where new ideas and technologies can challenge the current system. This structure helps to clarify the interactions between these components. It also lets the reader focus on specific areas, like promising changes in the niche or overarching trends in the landscape.

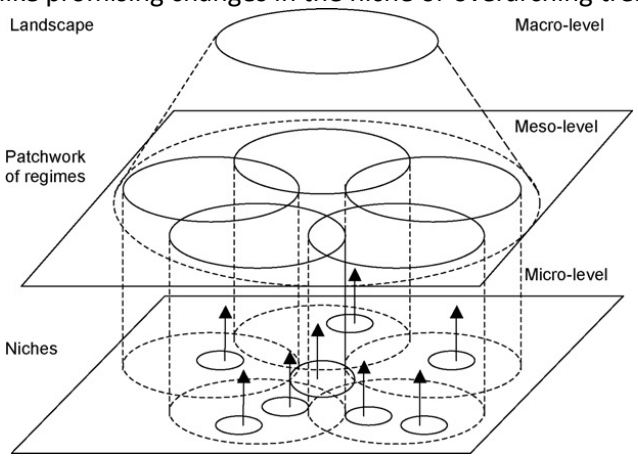


Figure 1: Multi Level Perspective model

The research employed a multi-faceted approach to explore sustainability and traceability in the Kenyan avocado industry. Guided by the Multi-Level-Perspective (MLP), the methodologies included literature reviews, interviews, stakeholder consultations, and visual evidence collection. The research focused on three primary levels:

- **Landscape**: Exploring global factors and demands, affecting the Kenyan avocado industry.
- **Regime**: Current state of the Kenyan avocado supply chain, including sustainable challenges.
- **Niche**: Feasible and applicable improvements for sustainability through traceability and transparency.

Results

Landscape: What are important global factors affecting sustainability and traceability in the avocado industry?

Avocado farming significantly contributes to Kenya's economy, which mainly relies on agriculture and tourism. While the industry has experienced growth, challenges around quality consistency, environmental impact, and worker welfare persist. Key global factors influencing the industry's sustainability include fair labour practices, improving rural livelihoods, and environmentally friendly farming. Traceability has emerged as a critical tool in ensuring product quality, fair work conditions, and ecological responsibility. In essence, traceability is the key to maintaining and demonstrating the standards that contribute to a sustainable avocado industry in Kenya, balancing economic growth with social and environmental considerations.

Sustainable supply chains are essential for businesses, incorporating social, economic and environmental sustainability into their operations Sustainability means different things to different people involved in the avocado supply chain. For consumers, it means knowing where their avocados come from and how they impact society and the environment. Retailers focus on selling high-quality, certified avocados that come from places with good work conditions. Importers of fruit in Europe aim to have high-quality, reliable supplies while also using resources efficiently. Avocado exporters in Kenya see sustainability as using farming methods that are good for the environment, educating their farmers, treating their workers well, and working well with other people in the business. Brokers focus on selling a lot of high-quality avocados for profit, without much focus on the environment or social benefits. For the Nandi farmer cooperative, sustainability means economic growth and using farming methods that are good for the environment. By understanding these different views, we can better manage the avocado supply chain in a sustainable way.

Understanding Dutch market's traceability demand is key for Kenyan avocado farmers hoping to export. This demand, driven by consumers wanting sustainable, ethically sourced products, is high among importers like “ Anonymus” and EOSTA. For them, traceability ensures food safety and quality, reducing waste and supporting economic growth. It's also vital for retailers like Jumbo, who need to verify sustainable practices and avoid issues like child labour. Compliance with traceability requirements, such as those in Jumbo's Corporate Social Responsibility report, is mandatory. Partnerships with initiatives like SIFAV further emphasize the need for sustainable, traceable produce to meet ESG reporting requirements.

Regime: What is the current state of the (domestic stages) Kenyan avocado supply chain, and how are various stakeholders including small-and medium scale farmers participating in sustainable solutions regarding traceability and transparency?

The Kenyan avocado business is a complex network involving various key stakeholders. These include:

1. Suppliers: These entities provide essential resources for avocado production, such as seeds, fertilizers, and tools.
2. Farmers: At the heart of this network are the farmers, who cultivate the avocados. One noteworthy group is the Nandi Avocado Cooperative, an assembly of thousands of farmers in Nandi County who've pivoted from traditional crops to avocados. They work together to boost production, manage costs, and navigate market demands.
3. Exporters: Major exporters like Sunripe Kenya and Keitt Exporters Ltd. purchase avocados from the farmers, grade them for quality, and ship them internationally. Keitt, known for its organic-certified avocados, handles a large volume of exports and also processes rejected avocados into oil. Sunripe, a competitor to Keitt, has a longstanding relationship with farmers and also exports a considerable volume of avocados weekly.
4. Brokers: Acting as intermediaries, brokers collect, grade, and distribute avocados from farmers to markets, contributing to the avocado supply chain's efficiency.
5. Retailers: The end-point of the supply chain, retailers sell the avocados to consumers in both local and international markets.
6. Ministry of Agriculture: This government body oversees the avocado supply chain, providing resources and support to farmers, and implementing structures like sub-counties and cooperatives to optimize productivity.

All these stakeholders, despite their unique roles, work towards a common goal - bolstering the Kenyan avocado industry, while managing challenges and maximizing sustainability and profitability.

Despite complexities in the supply chain, there's a strong drive for transparency and traceability. While some brokers resist these changes, fearing reduced profits, farmers and exporters are eager to improve. Certifications like EU Organics and Global GAP are seen as important for global competitiveness. Nandi Cooperative is ready to invest in a more traceable supply chain, which includes building their own packhouse to control product quality and gain market insights. This commitment indicates a positive shift towards a more sustainable avocado industry.

The complexity of the supply chain including the negative role of brokers is depicted in the figure below:

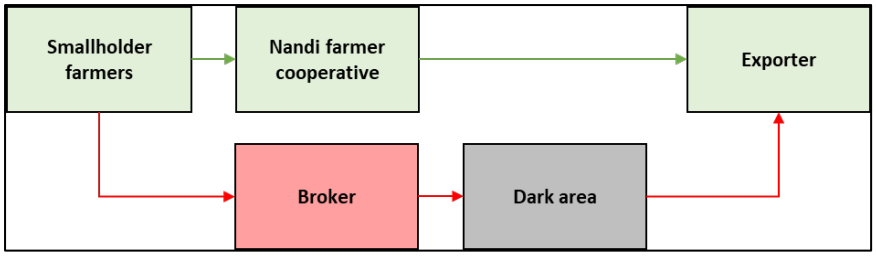


Figure 2: Supply chain complexity

Niche: How can traceability and transparency play a feasible role in improving sustainability (for small and medium scale farmers) in the Kenyan avocado supply chain?

Addressing supply chain complexity in the Kenyan avocado industry, contract farming establishes secure agreements between the cooperative and farmers, ensuring direct supply and full traceability. It provides farmers with price security and access to support services, fostering cooperative growth. The cooperative can also implement farmer clustering for knowledge sharing, improved quality, and efficient logistics. The adoption of ICT traceability solutions can enhance transparency and reduce costs. The Tanzanian "Eat Fresh" project offers a benchmark for connecting smallholder farmers to export markets through collaboration, capacity building, and innovative financing, demonstrating potential pathways for agricultural growth in Kenya.

Promoting awareness and willingness among stakeholders in the Nandi avocado industry requires a culturally sensitive approach. Appreciating Nandi County's cultural dimensions like power distance, collectivism, masculinity, short-term orientation, and restraint can enable the development of tailored interventions addressing gender inequality, poverty, and quality variation among small farms. To effectively engage the community, traditional practices and beliefs should be considered, utilizing the theory of change to overcome potential barriers. Collaborating with local students, who understand community language and culture, can facilitate clearer communication. Implementing visual aids and relatable storytelling can foster shared purpose and inclusivity, aiding the growth of the Nandi avocado industry while respecting its unique cultural heritage.

Improving traceability and transparency in the Kenyan avocado supply chain can be achieved through incentive-based solutions. These involve rewarding good practices and fostering changes. Utilization of technology, such as digitizing data, can streamline the process of tracking avocados from farm to market. Collaboration among stakeholders plays a vital role in ensuring smooth operations. Training programs enable farmers to adopt better farming and selling practices, and establishing direct connections with buyers assures fair prices. Introducing changes gradually, with consideration to local culture, is essential. The theory of change provides a useful framework for understanding problems, implementing effective solutions, and continuously refining strategies. Such an approach helps all parties understand the benefits of the changes and contributes to a more robust and transparent avocado supply chain.

Conclusion and Recommendations:

Conclusions

This research aimed to identify the issues that smallholder avocado farmers in Kenya face, especially inequities within the supply chain. The goal was to enhance traceability, transparency, and overall sustainability within the avocado supply chain. Using the multi-level perspective, it was found that European consumers, retailers, and importers demand traceable avocados due to international sustainability pressures. Given Kenya's reliance on agricultural exports, it's expected that the country will gradually adapt to these changing market needs.

However, field studies showed the complexities within the Kenyan avocado industry, including ingrained norms, farming practices, and power dynamics, which significantly impact product traceability. Transitioning towards a more sustainable supply chain may face resistance to change. Field studies suggested that farming contracts and enhancing stakeholder collaboration could boost traceability more efficiently than relying solely on technology.

This research predominantly focused on traceability within the Kenyan avocado supply chain, but it is important to recognize that there are other aspects, like socio-economic conditions and infrastructure, which also influence the sustainability and equity of the supply chain. However, these weren't extensively examined due to time constraints and a defined scope of research. Moreover, certain key stakeholders weren't included in the interview process, which could have provided a more comprehensive understanding of the industry's dynamics. Despite its limitations, this research provides a steppingstone towards understanding the complexities of the Kenyan avocado supply chain and potentially achieving sustainable improvements for all stakeholders.

Recommendations

Based on a thorough study of the Kenyan avocado supply chain, the following recommendations aim to assist " Anonymus" and FOQRLAB in enhancing the traceability and sustainability of the supply chain, considering their distinct roles and influence levels. The suggestions encompass potential collaborations, operational improvements, and emphasize the significance of sustainability and traceability.

The research advises " Anonymus" to explore collaborations with experienced Kenyan exporters like Keitt and Sunripe, who understand local supply chain dynamics and offer a reliable chain, unique product advantages, and a unique harvesting period, promising continuous avocado supply. Leveraging the Port of Mombasa for export provides cost and time efficiencies, while investing in traceability can streamline costs, enhance marketing, and enable stronger relationships with certified cooperatives striving for sustainable practices, thereby ensuring high-quality avocados and a resilient, traceable supply chain.

In the short term, FORQLAB is advised to enhance the foundation of cooperatives by encouraging member participation and collaboration, including establishing contract farming. For the mid-term, as cooperatives stabilize, the focus should be on digitalization, enhancing bankability, and transparency, leading to better financial trust and improved process investment. In the long term, obtaining organic certifications, aligning with global trends, should be prioritized to increase market value and appeal; this process also emphasizes the importance of traceability and technology utilization for transparency and broader sustainability.

Abstract for the project:

Reduction of waste avocados in Kenya

Part of the FORQLAB project

Written by: Nicolas Burger, Tijn van Staalduinen and Maureen van den Berg

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

June 23rd, 2023, Den Bosch | Project code: 22400512
HAS Green Academy

Project introduction:

FORQLABS is an initiative done in collaboration with Kenyan and Dutch universities, stakeholders from the dairy and avocado chains, and various other organizations. This project runs over a three-year period, students from six universities will work together to develop viable end products for the FORQLABS group to meet their aims. The project "Reduction of waste avocados in Kenya", was undertaken as part of the FORQLAB sustainability initiative, it aims to establish a more sustainable model for avocados in Kenya. The project focuses on reducing waste and improving processes throughout the supply chain. The main objective is to improve production processes, waste management, and marketing for 80% of small-scale farmers in the Nandi region of Kenya, benefiting both farmers and the entire supply chain.

This abstract provides an overview of the research report, summarizing key chapters and findings. It begins with a description of the initial research conducted to understand avocado waste within the Kenyan supply chain. Desk research, interviews, and excursions to industry companies were conducted, along with small-scale experiments on avocado oil extraction. A trip to Kenya was undertaken to gain firsthand knowledge of the supply chain, this took thorough preparation and research. The characteristics, types, nutritional value, health benefits, and advantages of avocado oil in cosmetics are discussed, along with the locations of avocado production in Kenya and the advantages provided by factors such as rainfall, harvesting season, and volcanic soil. The role of the Nandi Avocado Cooperation in the market and how they address challenges in Nandi County is also highlighted.

Research questions and methodology

The main research question of the project revolves around using avocado waste more efficiently in Kenya to add economic value and increase sustainability by developing products from the waste. The methodology for this research involves answering sub-questions related to growth management, waste management, and market investigation. These sub-questions explore topics such as improving crop management processes, understanding certification requirements and benefits to farmers, defining quality specifications for the European export market, identifying waste in the avocado sector, developing an alternative product from avocado waste, formulating a recipe for the potential product, identifying areas for improvement, selecting the most viable product, determining suitable markets (export or local), and planning marketing strategies and development processes. The methodology integrates literature research, desk research, field studies, interviews with farmers and industry partners, consumer surveys, and market analysis to gather the necessary information and develop a comprehensive blueprint for the project.

Definition avocado waste

The research report presents the results of the study on waste management within the avocado sector in Kenya. Initially, the definition of waste in the avocado sector was unclear due to varying interpretations across the supply chain which led to inconclusive results. Following a fieldtrip to Kenya, waste is defined as all avocados classified as grade 2 as they fetch such a low price. Grade 1 avocados, which meet the specific criteria set by exporters, are of the highest quality and mainly used for the export market, commanding a higher price. In contrast, grade 2 avocados exhibit lower quality, displaying physical damage or other issues, and are primarily used for oil production. The Nandi Avocado Cooperative purchases grade 2 avocados from farmers at a lower price.

Growth management

The study also found a significant knowledge and resource shortages among farmers in the avocado supply chain in Nandi, Kenya. This poses challenges for farmers as they struggle to produce avocados of the desired quality for the market. To address this issue, a growth management blueprint was developed, providing step-by-step guide on avocado cultivation and quality improvement. The blueprint emphasizes land assessment, considering factors such as altitude, climate, soil drainage, and pH levels. It also covers land preparation, seedling sourcing, planting techniques, pollination, harvesting practices, mulching, pruning, irrigation, disease and pest control, post-harvest handling, and storage techniques. Implementation of the growth management blueprint is expected to result in improved avocado quality, increased productivity, and reduced waste.

Marketing investigation and waste management

The report includes a detailed market investigation to select the most suitable product for development using rejected avocados. Consumer preferences, market trends, and potential profitability were considered during the product selection process. The investigation revealed a growing demand for sustainable and natural cosmetic products containing avocado oil (see figure 1), aligning with the global shift towards eco-friendly and organic cosmetics. Avocado oil is rich in vitamins, antioxidants, and fatty acids, making it a valuable ingredient for skin and hair care products (see figure 2). The report discusses the potential benefits and challenges associated with avocado oil production, highlighting the need for further research in scaling up production and optimizing the extraction process (see table 1).

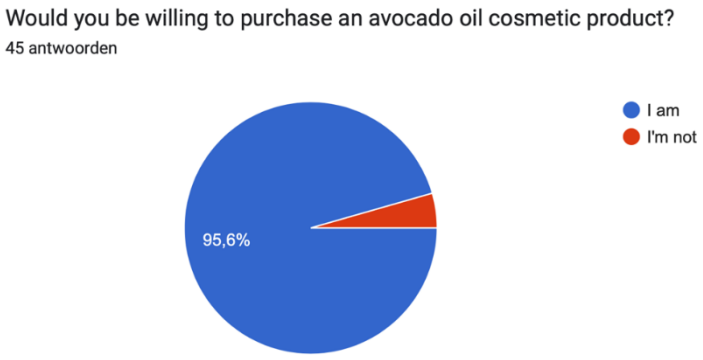


Figure 1: Survey (N=45)

Figure 2: Benefits avocado oil hair and skin; (Bee, 2023)

Table 1: Step by step guide

Step:		Visualisation:	Needed material:
1	Make sure the avocados are (over)ripe before starting		
2	Depit and peel the avocados		- Knife - Spoon
3	Puree the avocado flesh		- Hand blender or spoon
4	Warm the puree for 90 minutes at 40-50°C		- Pot - Stove - Timer - Thermometer
5	Scoop the mixture in the cheesecloth		- Cheesecloth - Gloves are recommended
6	Squeeze into the cheesecloth to strain the oil		- Cheesecloth - Gloves are recommended

Export criteria

Furthermore, the research report looks into the requirements needed for exporting avocados to the European Union (EU). Compliance with EU regulations is crucial for market access. The report provides an overview of EU regulations regarding quality, food safety, and traceability. It highlights the importance of Good Agricultural Practices (GAPs), Global G.A.P. certification, and integrated pest management systems to meet EU standards. Understanding these requirements is vital for small-scale farmers to enhance their export opportunities and gain a competitive edge in the market.

Recommendations

Based on the findings and analysis, the research report provides recommendations for addressing the issue of waste in the Kenyan avocado industry. These recommendations focus on implementing the growth management blueprint, fostering knowledge exchange and training programs for farmers, strengthening the Nandi Avocado Cooperative, improving waste management practices, enhancing traceability systems, fostering collaboration between avocado and dairy cooperatives, establishing avocado oil extraction facilities, and developing effective marketing strategies. By adopting these recommendations, the Kenyan avocado industry can reduce waste, enhance product quality, increase profitability, and contribute to a more sustainable and economically viable future.

Conclusion

In conclusion, the research report on "Reduction of waste avocados in Kenya" emphasizes the significance of implementing the findings and recommendations to transform the Kenyan avocado industry. The growth management blueprint, EU export requirements, avocado oil production potential, and marketing strategies discussed in the report have the potential to improve the industry in Kenya. By addressing waste management, improving quality, and strengthening market access, the Kenyan avocado sector will continue to grow, creating value for farmers and stakeholders, and promote sustainable development.

Finding the right product-market fit for avocados from the Nandi cooperative

Part of the FORQLAB project

Written by: Tom Engels, Tijmen Droog

25th January 2024, Den Bosch

Has Green Academy

Project introduction

Kenya positioned itself as one of the prominent global producers and exporters of avocados. Despite this, the avocado industry struggles with significant supply chain losses, estimated at approximately 35%. This FORQLAB project is initiated with the primary aim of reduce post-harvest losses within Kenya's avocado supply chain, ultimately contributing to the overall efficiency of food systems. This research focusses on identifying the right product-market fit for avocados from the Nandi cooperative, with the objective of minimizing post-harvest losses throughout the supply chain. The report first shares background information about the FORQLAB initiative, Kenya's food sector, Nandi County and the global avocado production seasons. Once the reader has a better understanding about the project, the supply chain of Nandi is analysed.

Data collection

Desk research

The secondary data for this study is gathered through desk research, specifically by conducting a comprehensive review of existing scientific reports, studies, and articles. It is important to note that the majority of the scientific reports utilized in this study are peer-reviewed, meaning that they have undergone a rigorous evaluation process by experts in the field who possess in-depth knowledge of the subject matter. This ensures that the information derived from these reports is of high quality and is researched for scientific validity, methodology, and analysis. Incorporating peer-reviewed reports enhances the credibility and reliability of the research findings.

Interviews

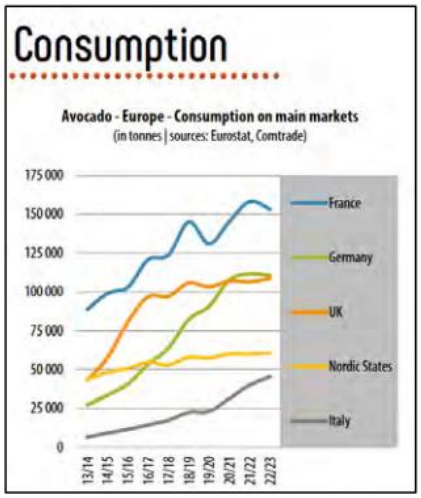
The interviews yielded information about internal factors of the cooperative, the supply chain, price margins, the competitive landscape, avocado varieties and annual production. Three interviews with importing companies are utilized. These interviews offer insights about price margins, market requirements in Europe, product specifications per industry and external factors of the industry. The interviews per industry are used to gain information about price margins, market requirements in Europe, product specifications per industry, external factors of the industry and potential markets. The insights gathered from interviews are converted into a summary available in the appendices of the main report.

Results

The supply chain analysis entails the structure of the supply chain, the price margins of each stakeholder in the supply chain and the competitive landscape of the supply chain. From the analysis of the supply chain, it can be concluded that the cooperative's payment system encounters

significant delays, primarily due to the current involvement of the bank in the payment process, taking up a few days. This results in farmers choosing not to sell their produce via the cooperative due to the delayed payment process for avocados, choosing instead to sell directly to exporters in cash. The bargaining power between farmers and exporters is unbalanced, with exporters holding a dominant position in the supply chain. The exporter's strong influence is primarily attributed to their control over farmer education regarding avocado cultivation practices. Additionally, the exporter serves as the decision-maker for quality standards, deciding which avocados are export-worthy and imposing costs on farmers for rejected fruits.

To match the product with the right market, an analysis of the avocado specifications from Nandi is needed. The avocado specifications include details on quality classifications, varieties and volumes. There are two different classes in Nandi which are first-class and second-class. First-class meets the extra class criteria from European standards and is therefore suitable to be exported to the EU. Second-class does not meet the requirements of the EU standards and is therefore not exported to the EU but to other continents or the oil industry. Additionally, the volumes of the Nandi cooperative are too low to meet export volume demands.



The European markets are explored through market segmentation analysis. The market segmentation centres on the European avocado market, with a specific focus on organic avocado
markets in Europe. The European market segmentation shows that France has the biggest market
for avocados followed by the UK and Germany. Analysing the European market for fresh avocados reveals notable insights. There is potential for organic avocados in the German market, driven by consumers' aversion to artificial fertilizers and pesticides. The German market is open to fruits and vegetables with skin abnormalities, providing an opportunity for avocados from Nandi. Additionally, the German government's agricultural policy stands out, showing a commitment to sustainability and prioritizing organic farming. Notably, Germany aims to allocate 30% of its agricultural land to organic farming by 2030, showcasing a significant opportunity for organic market growth.

Research is being conducted on the market requirements for exporting to Europe. This involves identifying the minimal market requirements for exporting to Europe, followed by a more in-depth sector specific analysis of market requirements in Europe. The minimum quality requirements that must be met are the UNECE standards, this includes all quality details. The UNECE standards handle three different quality classes. The best quality class is the extra class, the second best is the class I, and the third best is the class II. During the research of the three industries, there are significant results discovered concerning quality specifications. The retail and food service industry only handle the extra class avocado, the market for the class I avocado within these industries

exists, but its share is very little. However, The organic industry handles product specifications with less high standards. The class I avocados are the norm within this industry, which means that there is room for some abnormalities on the fruit. The extra class does not exist within this industry, which means that the best quality class available in this industry are the class I avocados. The class II avocados are also sold in the organic industry, but these quantities are smaller.

The future position of the Nandi cooperative is analysed by using several different tools including the SWOT analysis, Blue Ocean Strategy, Porter 5 forces and scenarios. Improvements in certain areas are essential for the cooperative's future growth and development. The absence of a sorting facility is the root cause of the low quality and lack of uniformity for avocados from Nandi. An investment in a sorting facility creates the opportunity to deliver a uniform product in the future. Currently, the Nandi cooperative's aspiration to source directly in the future faces challenges as the volumes are insufficient to fill a container. Furthermore, improving the organizational structure is essential for establishing partnerships with international companies. Finally, the Nandi cooperative is applied within four different business scenarios in which they could potentially find themselves in the future.

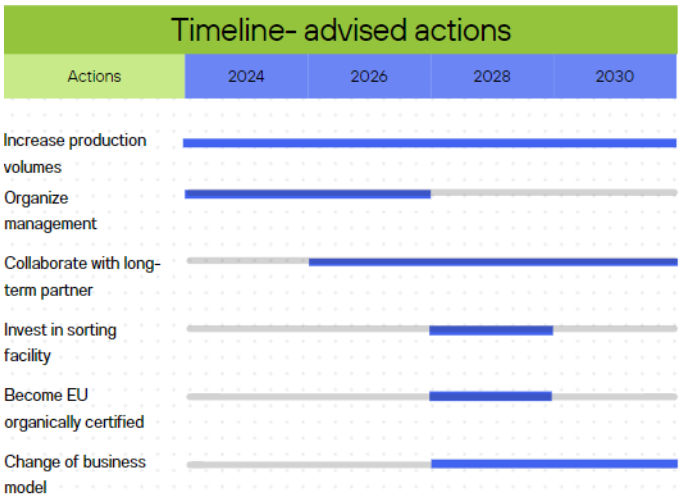
Conclusion

The most important outcomes of the research are listed below.

- The cooperative's payment system encounters significant delays, primarily due to the current involvement of the bank in the payment process. Payments that are handled via the bank take up several days. This results in farmers choosing not to sell their produce via the cooperative due to the delayed payment process for avocados.
- There is big potential for organic avocados in the German market. The German market presents an opportunity for avocados from Nandi due to the preference of German customers for organic produce and their aversion to the use of artificial fertilizers and pesticides. Additionally, Germans are known to be more accepting towards fruits and vegetables that have lower overall quality.
- In order to export to the European market, avocados must meet the minimum quality requirements set by the UNECE standards. These standards, established by the United Nations, outline specific criteria for quality, including acceptable levels of skin and pulp abnormalities when exporting to Europe.
- The research conducted on three distinct European industries revealed significant findings regarding product specifications. The retail and foodservice handle avocados with the highest quality standards. These industries primarily deal with avocados classified as extra class, with only a minimal market share for avocados categorized as 'class I'.
- The organic industry has relatively lower product specification standards, which could potentially facilitate entry into this market. Within this industry, 'class I' avocados are generally accepted, allowing for some abnormalities on the fruit. Unlike other industries, the 'extra class' avocados are not recognized in the organic sector.

- The absence of a sorting facility is the root cause of the low quality and lack of uniformity for avocados from Nandi. A sorting facility creates the opportunity to deliver a uniform product to the exporter.

Recommendation



Based on the conducted research, several pieces of advice are provided to the Nandi cooperative. On the short term, the Nandi cooperative needs to improve its organizational structure by providing clear descriptions of roles and responsibilities. Improved communication, documentation, and payment systems are also essential to ensure execution of business activities. Additionally, the production volumes need to be increased in order to meet specified requirements for container shipments. On the longer term, the Nandi cooperative should actively seek a long-term collaboration with a partner willing to invest in its supply chain. Such a collaboration has the potential to bring valuable expertise and resources to the cooperative. Additionally, it is recommended that the Nandi cooperative invest in a sorting facility. The implementation of such a facility will improve the overall quality and uniformity of avocados. Furthermore, it is suggested that the Nandi cooperative becomes EU organically certified in the future. The move towards organic certification holds numerous advantages for the cooperative. Finally, it is recommended for the Nandi cooperative to change its business model towards organic production and serving niche markets. The scenario in this research showed that this business model aligns well with the current cooperative's production capabilities.

Curriculum Development Using the Principles of Competency Based Training

Daan Westrik, Marjo Baeten

Practice Brief
FORQLAB Project 2024-04

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

Curriculum development using the principles of competency-based training focusses on three different elements. These elements are the curriculum, the learning process, and the assessment.

The curriculum

Competency based training is students centred, task based and competency oriented.
To ensure the curriculum is task based different steps were used to design a curriculum based on the principles of competency-based training. These steps are the analysis of the labour market to identify job descriptions and professional tasks. Then selecting competencies for each professional task, selecting professional tasks and constructing the curriculum blueprint. And finally, the design of the assessments, the design of the learning task and formulating practicals. And lastly the selection of relevant theory.

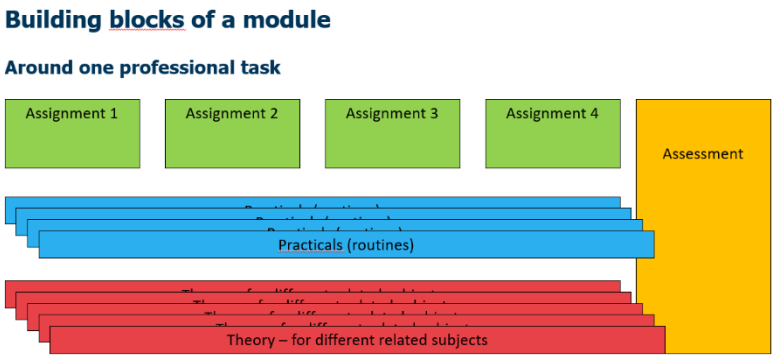


Figure 1: Building blocks of a module

Professional tasks

The purpose of the labour market analysis was to find the professional tasks for which the students need to be trained for. A detailed map of the value chain is made to provide information about the relevant jobs and professional tasks. This analysis resulted in a long list with different professional tasks.
Based on this longlist with professional tasks a selection is made. The selected professional tasks are relevant for the domain and the level of education the curriculum is aiming at.

Competencies

Because the curriculum will be competency oriented it's required to identify which competencies are needed to perform the different professional tasks. For this purpose, a list with ten generic competencies is used. Then, a limited number of professional tasks is selected by ensuring the ten different competencies are covered equally.

With the selected professional tasks, a curriculum blueprint is made. This curriculum blueprint presents which professional tasks is going to be trained in which part of the curriculum. For example, first year or second year, first semester or second semester. And the amount of study time available for each professional task is defined.

Curriculum development step by step:

1. Analysis of labour market
2. Identify Job descriptions
3. Identify Professional tasks

4. Assign competencies per professional task
5. Selection of professional tasks
6. Design curriculum blueprint

7. Develop assessments
8. Design learning tasks
9. Design practical's
10. Select relevant concepts or theory

11. Prepare Learning guides + Teaching guides

Figure 2: Steps for curriculum development

The amount of study time is related to the total amount of study time per academic year, and it includes all study activities of the student. Besides instruction in class also time required for individual study and assignments is included. Each professional task represents one module.

A curriculum based on tasks ensures that students gain experience and skills to perform professional tasks after graduation. Orientation on competencies ensure that students become flexible in performing related but different professional tasks making them flexible for a changing labour market.

The development of the different modules of the curriculum consists of the development of assessments, learning tasks and practicals. It also consists of selecting the relevant theory to be taught.

Assessments

Assessments will be based on the professional tasks and are a summative assessment to evaluate whether the student is able to execute the specific professional task. This assessment will therefore be performed at the end of a training period. For the development of the assessment a format is used.

Learning tasks

To ensure students gain experience in executing the professional task to be tested with the assessments a couple of learning tasks is developed. These learning tasks are assignments which by executing them provide experience in performing the professional task and the assessment.

Learning tasks consists preferably of the different steps needed to execute the professional task (and so the assessment). Which gives the students the possibility to gain routine in performing the task. Starting with learning tasks with a low level of complexity and finishing with learning tasks with a high level of complexity. At the same time starting with learning tasks with a low level of guidance and finishing with learning tasks with a high level of guidance.

Practicals and theory

The execution of learning tasks might require specific routines or skills. These skills will be trained in practicals. For a proper execution of learning tasks (and the assessment) knowledge might be required. The assessments and learning tasks will therefore direct which theory needs to be taught prior to or during the execution of learning tasks.

Four FORQLAB modules designed

Applying the above-described method for curriculum development 4 modules are developed to train students on the ability to contribute to food loss & waste reduction. Two modules are related to the dairy value chain and two modules are related to the avocado value chain.

For each module a specific professional task to be trained is chosen. For the two avocado modules these professional tasks are Marketing officer and Quality inspector. And for the dairy modules the chosen professional tasks are Extension and Quality control.

For each module a learning guide is designed. These learning guides contain a description of competencies to be trained, four or five learning tasks, a description of the assessment and a description of theory to be offered to support the execution of learning tasks and assessment.

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Pilot avocado shipment of 4 united avocado cooperatives

Peter Bouma

Practice Brief
FORQLAB Project 2024-6

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

HAS green academy

Introduction or rationale

Incredible what cooperation in the value chain can achieve and how impressive the export initiative of the small-scale avocado farmers' cooperatives from Nandi County and 3 from Meru country is (Mount Kenya, Mount Kenya east, Abothucuchi). Impressive also because of the results of the FORQLAB project (https://ap.lc/oqmxB). This project started two years ago and aimed to reduce food waste and loss in Kenyan food systems. The avocado product was chosen as an example product at the time. An applied and business approach has been chosen and besides farmers, companies and governmental organizations were also part of the project. Interviews with avocado farmers showed that many losses occurred because of (too) poor planning, communication, and coordination in the value chain. Knowledge of the value chain and the market was also insufficient. The result of the analysis led growers to express their ambition to export independently. In addition to wastage, this may also result in a higher living wage. The four cooperatives joined forces and jointly decided to send a trial shipment to the tropical fruit import company and project partner, Special Fruit NV in Belgium. Nandi Avocado Farmers' Cooperative Society (NAFCS) managed to apply for an export licence at short notice, which was jointly availed.

Business case pilot

On the 14th of July 2024 the 4 cooperatives sent their first shipment in close cooperation with project partner Airflo Ltd. to Europe and they succeeded! Despite skepticism and prejudice locally and in the market. The objective of the shipments was to understand the supply chain and the needs of the value chain partners. The results were beyond expectations! Only 2% of the avocados did not meet class 1. The dry matter percentage was at average 27%. A very good result. The results prompted the growers to continue their own exports in the future. Certainly, there are several areas for improvement being indicated by both Airflo Ltd and Special Fruit. The cooperatives are jointly of the opinion that the feedback and suggested process improvement can be implemented.

Results:

Positive Points

- Clean Fruit: The fruit was generally clean, without blackspot and stem-end, which is crucial for good ripening and reduction of dropout.
- Peel damage: There were only a small number of avocados with severe peel damage, which is positive for fruit quality and marketability.

Areas for improvement

- Mix Palettes: The use of mix palettes with different growers per pallet can lead to inconsistencies in ripening, which is not good for fruit homogeneity.
- Inhomogeneous Ripening: It has been observed that ripening within boxes is not homogeneous, probably due to differences in dry matter or picking date as a result of the mix pallets.
- Additional Costs: Inconsistent ripening leads to higher costs due to additional sorting and multiple ripening before the fruit can be delivered to the customer.
- Wrong grading: Several boxes had wrong grading markings on the outside, which is misleading to us and leads to higher sorting costs and possible claims.
- Packaging Quality: The quality of the boxes needs to improve; after maturing, the boxes almost fell apart as the glue came off in several places.
- Lenticell Issue: Lenticell is not accepted by all customers, meaning it needs to be sorted out.

Next Steps

- Formalization of the collaboration between the four cooperatives. The cooperatives will unite in a union.
- A strategic plan will be developed. The objective is to set the long-term objectives and decide about the joined strategies to realize the financial, marketing & sales and operational strategies.
- Taste and Quality Testing: The flavor and other quality aspects of the avocados are yet to be tested to ensure final customer satisfaction.
- Large-scale Testing: Real testing can only begin when large quantities are available, which means there is still a lot of uncertainty about the final results on a larger scale.

Conclusions

The main advantage was that the avocados were clean and had little serious skin damage. However, the problems with mix pallets and therefore inhomogeneous ripening, extra costs due to sorting, incorrect grading designations, the lenticell issues and poor packing quality make it clear that significant improvements are needed to optimize the ripening and delivery of avocados to the customers of the importer. Thus, reasonable steps must be made by growers. Still, to reach a minimum standard to make this work on a financially viable scale, improvements must be made.

Roadmap To Food-Loss Reduction, Entrepreneurship, and Sustainability for Nandi Avocado Cooperative

Practice Brief
FORQLAB Project 2024-14

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

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Introduction

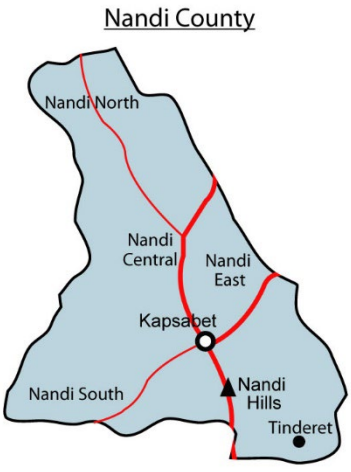
Based on the food loss audits conducted by Master students, the scoping study Nandi avocado farmers' cooperative society (AFCS), executed by Agriterra in December 2022, and interviews with the CEO, consecutive student teams of the Master Horticulture Chain elaborated pathways for further development of the Nandi Cooperative Society.

Nandi Avocado Farmers Cooperative Society

Cooperative description (Agriterra 2023).

Nandi Avocado Farmers' Co-operative Society is an avocado value chain-based cooperative that is in Kapsabet town, Nandi County in the Rift Valley (Figure 1). The cooperative attracts members from all six sub-counties in Nandi County. It was started and registered in 2019 by 36 members who aimed at bulking together their avocados for joint marketing and better bargaining power in prices. Before the cooperative was started farmers used to sell individually to brokers and in local markets. At times the farmer would lose their fruits in the process because of being under the mercy of the brokers who would collect at pleasure and with very low prices, this would lead to a lot of wastage of the ripe avocados due to market challenges. With the support of the NARIGP project, run by the world bank, together with the Ministry of Agriculture the farmers decided to join together and form a cooperative. Membership has since grown over the 2 years to 806 as of December 2022.

Figure 1: map of Nandi Country



The society owns 1 acre of land that was bought through members' share purchases, they collected Ksh 1.7M. Currently, the cooperative is using the National Government offices in Kapsabet but plans to build its own offices in the future. There are plans to set up a packhouse and a cold room which they can use for aggregation and marketing of their products on the land they bought. This will help the farmers to increase their bargaining power as they would sell collectively.

In 2020 the society was given a grant of Ksh 1.5M by the NARIGP World Bank Project which was used in Capacity building and the purchase of office equipment. In the same year, the cooperative signed a sales contract with Virgin Fruit Limited as an off taker, he only collected 2.7T of grade 1 Avocado from the farmers, and the farmers sold the rest of the produce to the local market. In 2021, the cooperative

signed another sales contract with Sunripe 1976 which collected 10.9T out of 110.9T produced. Fuerte - Kshs 50/per kg; Hass-Kshs 80 per kg; Grade 2 @ Kshs 15/ per kg, thus for oil processing.

The farmers suffered very huge losses as they had to sell the remaining quantity to brokers and the local market at very poor prices i.e (12 Kshs/kg). In 2022 they sold a total of 81,124T of their produce to Sunripe and Keitt exporters. There were still losses incurred as some farmers still planted varieties that were not exportable, some fruits were infected, and others were too small to be exported. The Society has signed a new contract with Sunrise 1976 for 2023 buying at Fuerte 50 Kshs/kg, and Hass 100 Kshs/kg, and grade 2- 15 Kshs per kg. They have agreed to employ four agronomists to train the farmers on Good Agricultural Practices (GAP) and Climate Smart Agriculture (CSA) practices such as the use of high-quality, well-adapted Fruit Tree Seedlings, Sustainable Soil and Land Management and Biodiversity Management as a solution to reducing the food losses incurred during the previous seasons by 90%.

Cooperative analysis

Two consecutive student groups made an analysis of Nandi Cooperative, using the value chain map (Figure 2) and problem tree (figures 3 and 4) as analysis tools.

Figure 2: Nandi AFCS value chain map (student team 2022-2023)

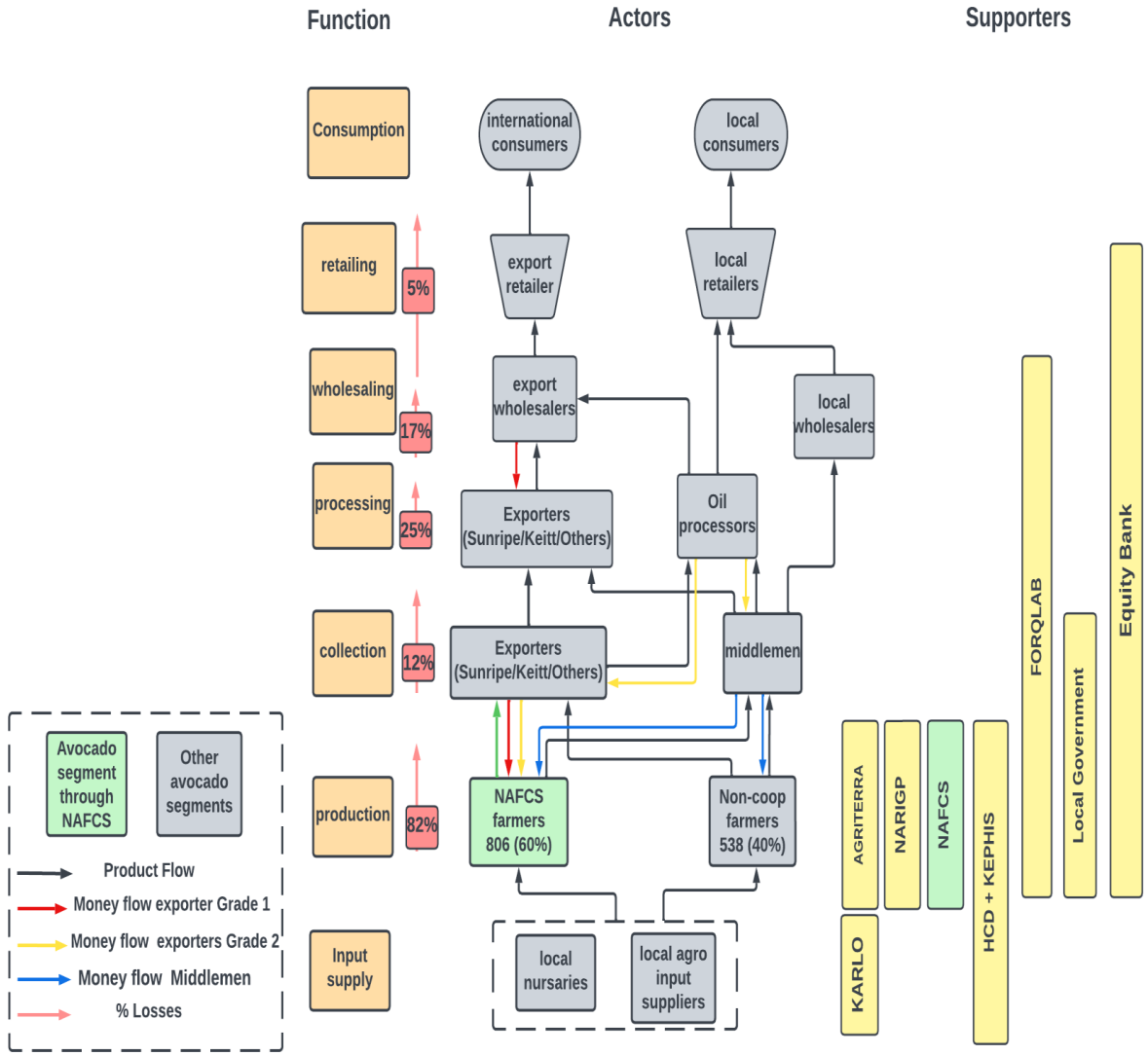


Figure 3: Problem Analysis Nandi cooperative (student team 2022-2023)

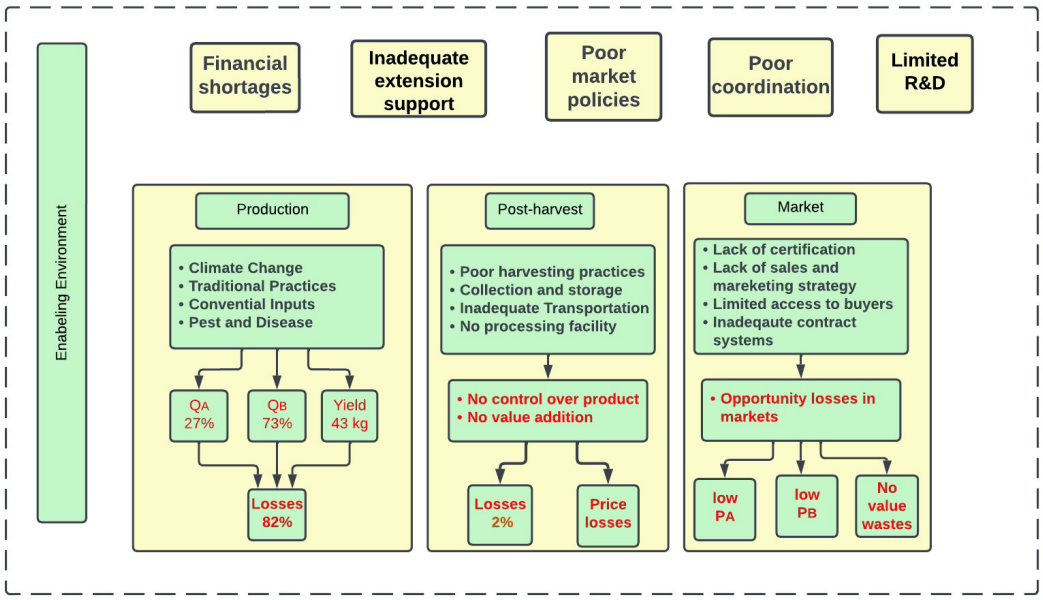
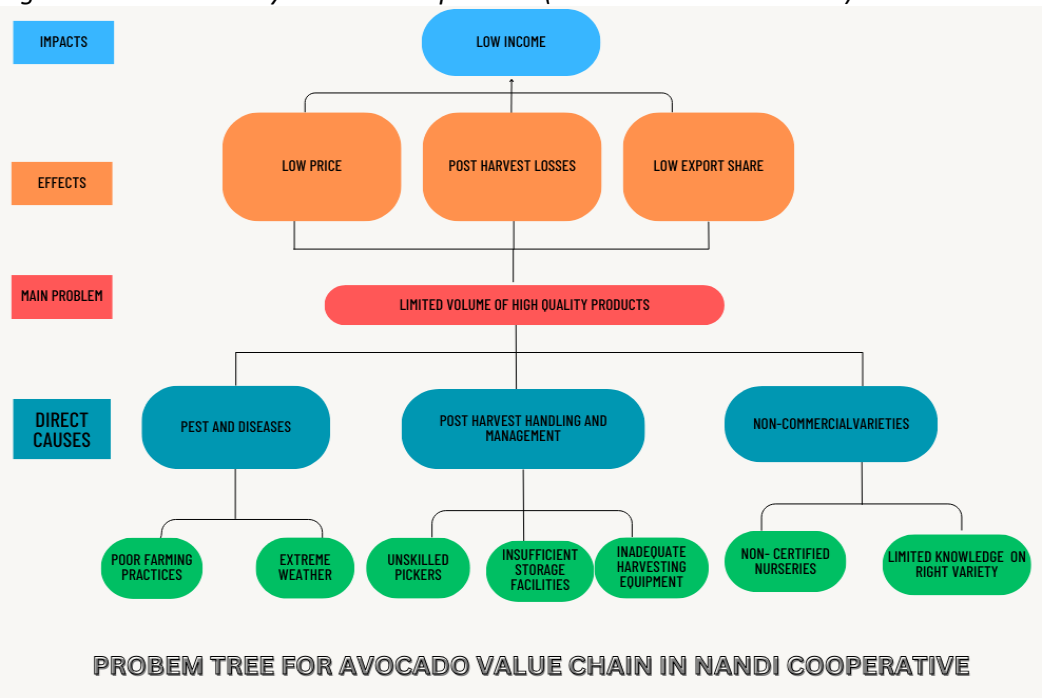


Figure 4: Problem Analysis Nandi cooperative (student team 2023-2024)



Proposed interventions

Students proposed the following interventions (Figure 5-7 - student team 2022-2023), including a warehouse design (Figure 8) and (Table 1 – student team 2023-2024):

1. Improve production yield and quality of avocado produced and increase member involvement and enhance productive capacity and resilience to sustainably produce.
2. Reduce post-harvest losses, control product flow, and improve the quality of avocados thereby increasing the percentage of volumes sold in the Export Market.
3. Diversify sources of revenue and increase sales by targeting new export markets and by vertically integrating relations between local customers and oil processing firms.

Figure 5: Proposed intervention 1

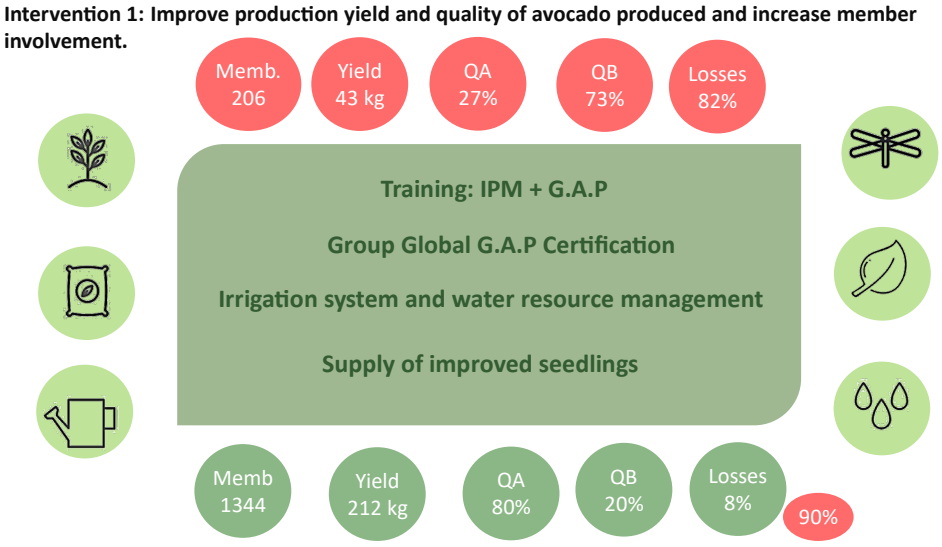


Figure 6: Proposed intervention 2

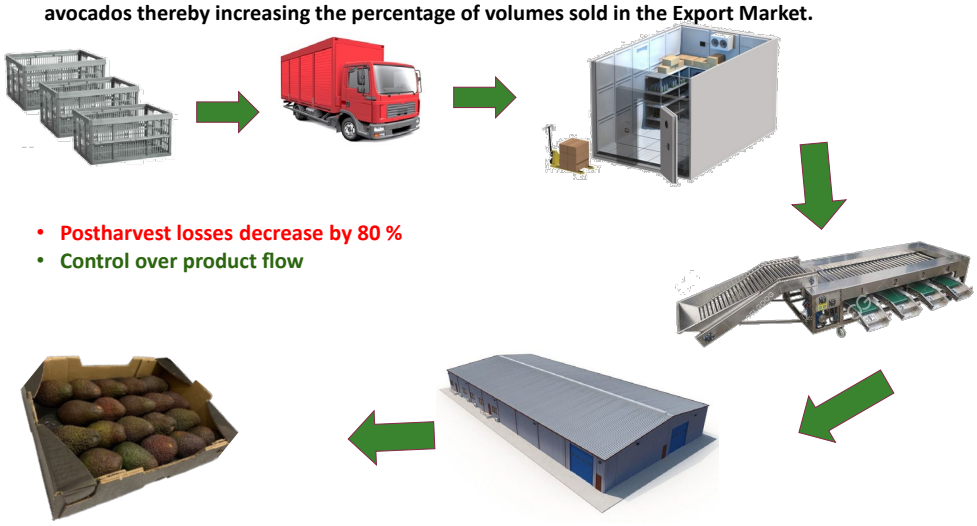


Figure 7: Proposed intervention 3

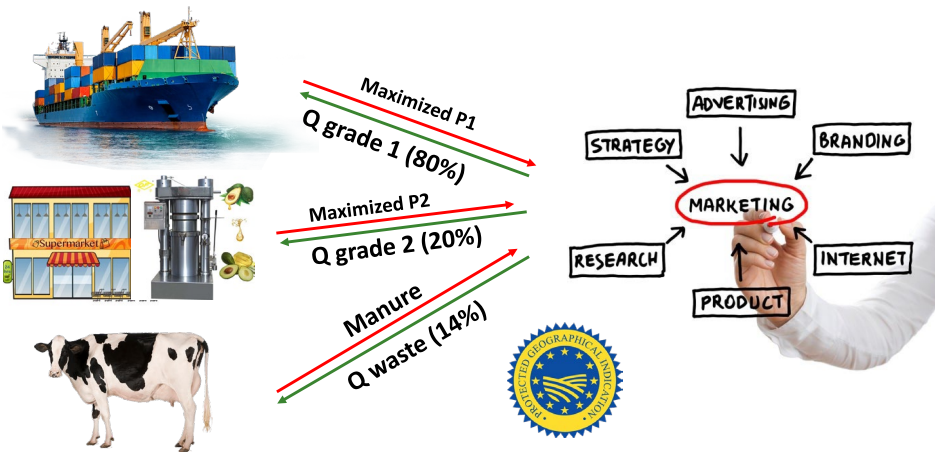


Figure 8: Proposed warehouse design (student team 2022-2023)

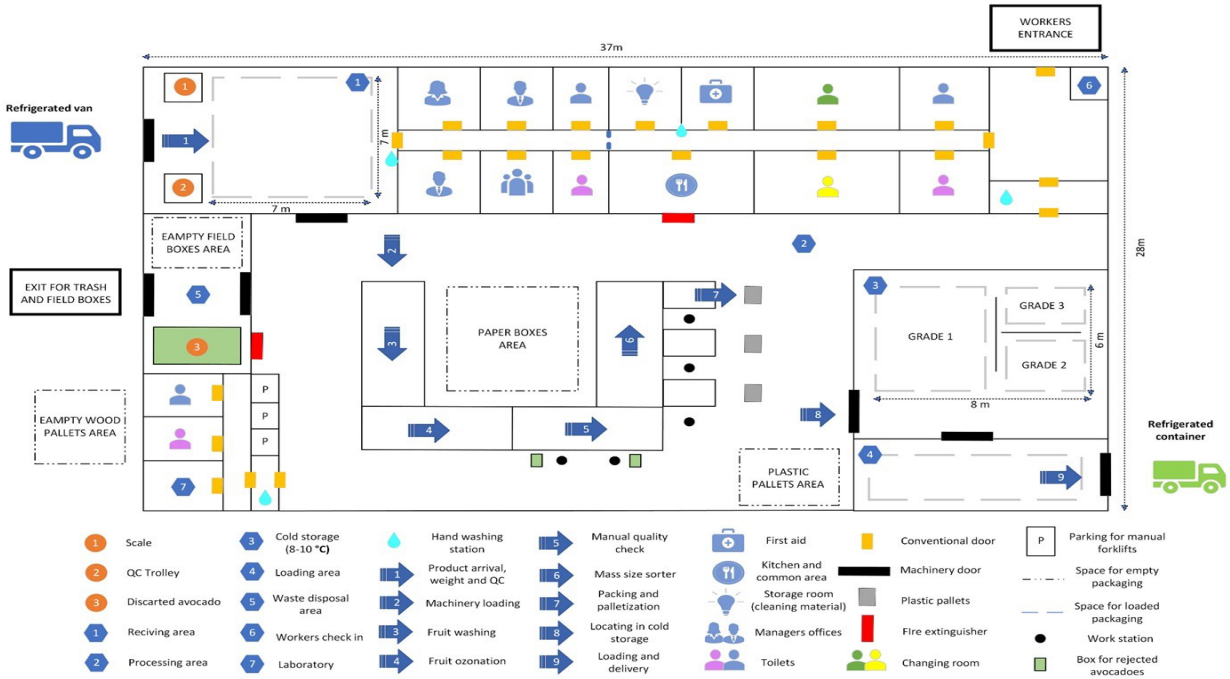
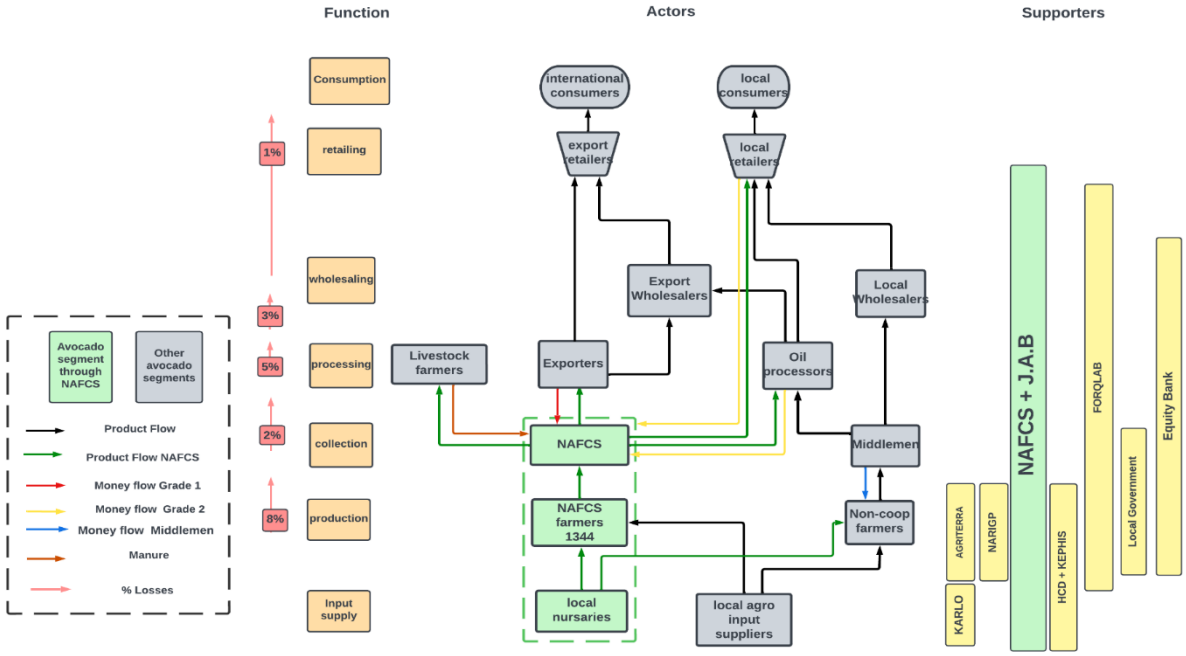


Table 1: Proposed interventions (student team 2023-2024).

INTERVENTIONS	ACTIVITIES
Enhance the operational capability of NANDI Avocado farmers' Cooperative	• Hire management team • Improve infrastructure system • Capacity building of farmers on GAP and post-harvest handling • Facilite access to quality inputs (right seedlings, fertilizer, harvesting equipment)
Strengthen Market Linkages and value addition	• Conduct market research to identify demand trends and potential buyers • Facilitate local and international market • Improve traceability and develop branding systems to ensure product quality and safety.
Organic production of avocado	• Identify potential competitors, discern market trends and consumer preferences. • Obtain organic certification to establish a unique selling point (product differentiation).
Introduce Farmers Field School	• Introduce the concept of farmers field school by farmers' training, model farmers, and follow up.

Figure 8: Proposed new chain



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Avocado Value Chain Development in Mt. Kenya

Practice Brief
FORQLAB Project 2024-15

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

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Introduction

Based on the food loss audits conducted by Master students, the scoping study Mt. Kenya avocado farmers' cooperative society (AFCS), executed by Agriterra in December 2022, and interviews with the CEO, consecutive student teams of the Master Horticulture Chain elaborated pathways for further development of the Nandi Cooperative Society.

Mt. Kenya Avocado Farmers' Cooperative Society - *Cooperative description* (Agriterra 2023).
Mt. Kenya Avocado Farmers' Cooperative Society is an Avocado cooperative located in Meru County (Figure 1). It started in 2021 by avocado farmers within the Meru region with assistance from the county government with 52 members after they decided to come together to sell collectively since the brokers were offering very poor prices and the produce was available but there were no markets. The cooperative does not have an office.

Figure 1: map of Meru Country

In March 2022, the cooperative negotiated with KEITT and Sunripe 1976 who picked 1T and 3T respectively. KEITT picked Hass and Fuerte varieties while Sunripe 1976 picked Hass at an average price of 17shs/ avocado fruit. There was no contractual arrangement, and the exporters collected the fruits from the farm and paid the farmers directly via M-pesa. The payment was lower than the agreed price as the exporters sorted and graded the fruits again rejecting several kilograms. KEITT exporter rejected 300Kgs while Sunripe 1976 rejected 500Kgs and this caused very huge losses. The cooperative

was disappointed with the double grading and is currently negotiating with exporters offering better prices with a contractual agreement.
The cooperative is also in negotiation with the county government to lease a packhouse belonging to the county government at Mugamboni so that it can help them to aggregate, sort, and grade before the exporter picks to avoid losses from double grading and poor handling techniques. The poor-quality fruits will be sold to the local market, and this will reduce the losses for the export market.

The cooperative is mobilizing more members within the region to join the cooperative and increase the number of trees planted to increase production and meet demand. Currently the cooperative is negotiating with Emelli Enterprises and Tripple A growers exporters for the next harvesting period (March-September).

Cooperative analysis
Two consecutive student groups made an analysis of Mt. Kenya Cooperative, using the value chain map (Figure 2) and problem tree (figures 3 and 4) as analysis tools.

Figure 2: Current Mt. Kenya AFCS value chain map (student team 2022-2023)

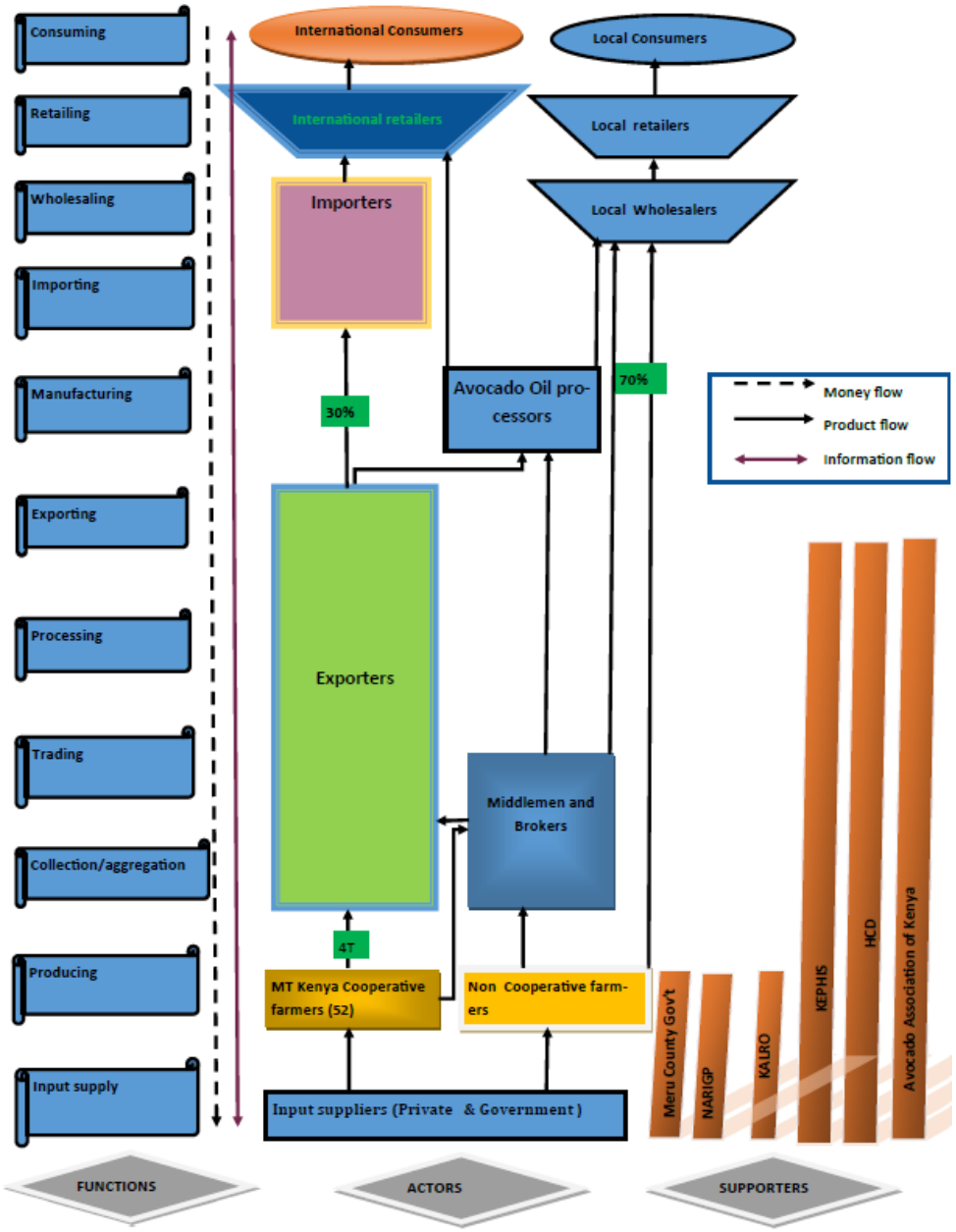


Figure 3: Problem Analysis Nandi cooperative (student team 2022-2023)

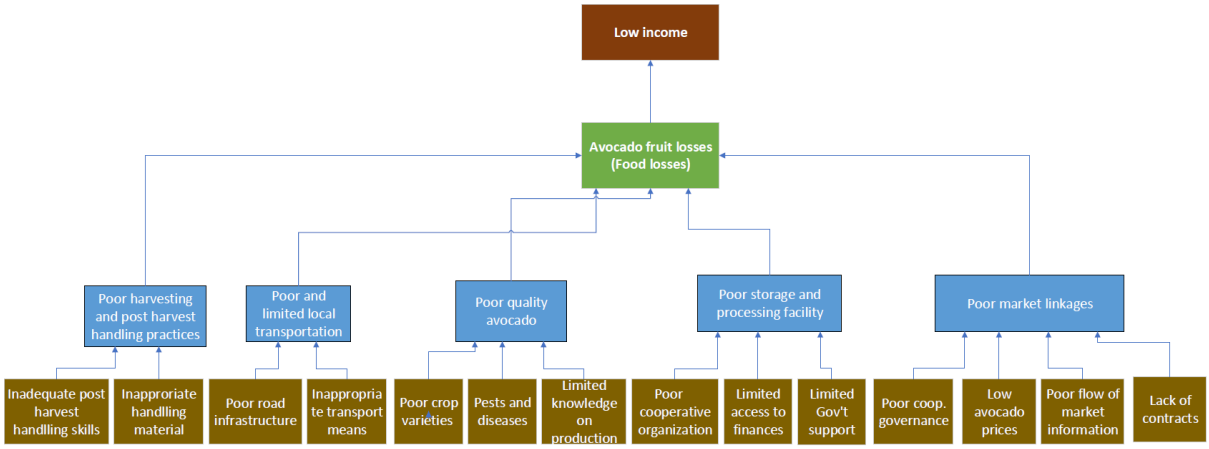
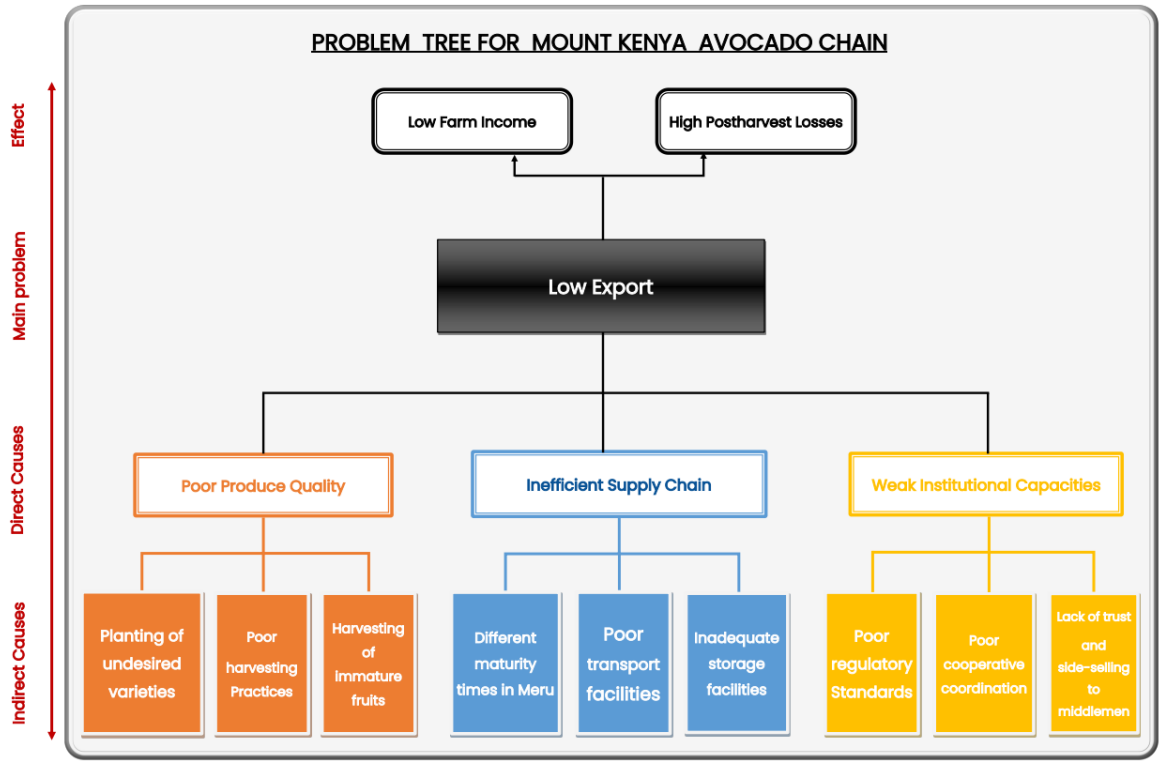


Figure 4: Problem Analysis Nandi cooperative (student team 2023-2024)



Proposed interventions

Students proposed the following interventions (Table 1 - student team 2022-2023; Table 2 – student team 2023-2024):

Table 1: Proposed interventions

Problem	**Possible intervention**
Post-harvest losses	Improve post-harvest handling.
Low product volume	Increase production and productivity of the trees.
Limited and poor transport means	Improve transportation services.
Low quality products	Improving quality of products sorting, grading, and packing
Limited market access and low prices	Improve market information systems.

Table 2: Activities and Expected Outcomes

ACTIVITIES	INTERMEDIATE OUTCOME	ULTIMATE GOAL
• Have an MoU with Meru University and Kaguru to supply farmers with desired seedlings at a subsidised price. • Establish a cooperative-owned harvest team with regular members trained to harvest the avocados.	Improve produce quality	Increased Export of Avocado & Reduced losses
• Provide a common platform for key actors in the supply chain to be in constant communication. • Provide multi-layered plastic crates to the cooperative for transporting avocado fruits. • Provide an adequate storage room for aggregating avocados.	Efficient Supply Chain	
• Acquire an office for the cooperative • Provide logistics, marketing, accounting, and other technical services for the cooperative for the first three years while we train cooperative members to take up those roles from the 4th year. • Community outreach to offer resources and expertise to help farmers diversify their crops or income streams, reducing reliance on side-selling.	Strengthened Institutional Capacity	

Figure 5: Proposed warehouse design (student team 2023-2024)

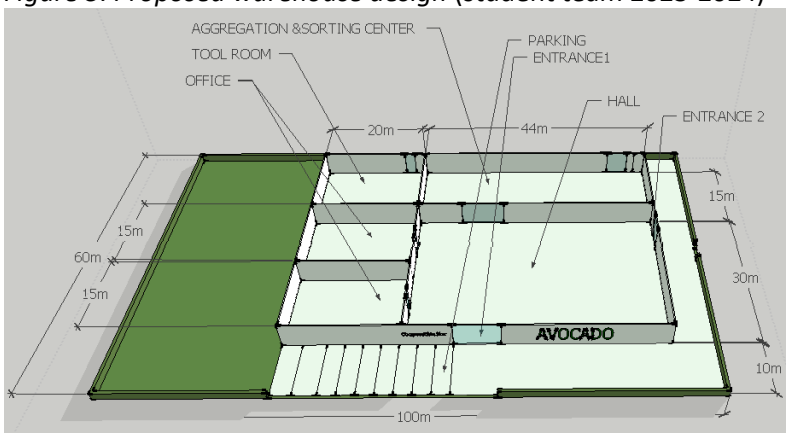
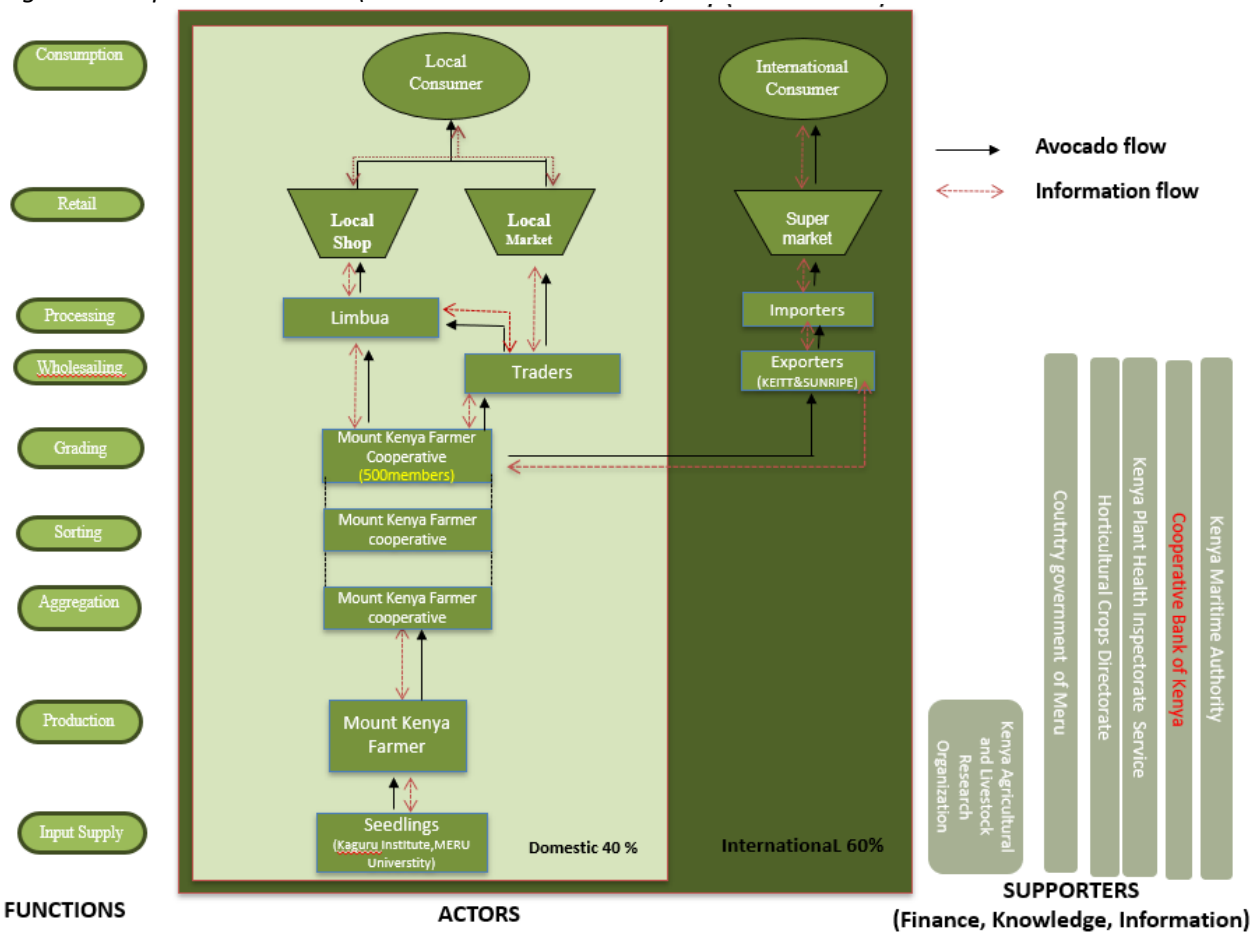


Figure 6: Proposed new chain (student team 2023-2024)



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Improving communication and coordination through an information and communication application within the avocado cooperatives in Meru County, Kenya

Kareemat Opeyemeni Fakorede, Albertien Kijne, Marco Verschuur

Practice Brief
FORQLAB Project 2024-02

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

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Introduction

The agri-food sector accounts for 34% of Kenya's national GDP and 65% of all export-related earnings, including avocado exports (Snel et al., 2021) and over 80% of the Kenyan population is directly dependent on agriculture as a source of living (Snel et al., 2021; Ireri et al., 2021). Small-scale producers, spread across central highlands, south of the Rift Valley and western Kenya majorly do avocado cultivation (Murithi, 2024).

Since 2017, Kenya has been Africa's leading avocado exporter (Avocado Society of Kenya, 2020), and ranks currently as the fifth largest producer globally with a volume of 458,440 metric tonnes (Statista, 2024)

As one of the leading producing regions in Kenya, the avocado value chain in Meru County has witnessed significant growth in recent years. As the production and consumption of avocados continued to increase significantly in recent years and there is a consistent expansion into diverse markets, there is a necessity for effective distribution and coordination within the chain (Kourgialas, 2021).

Coordination and communication are functions of each other and critical for a well-functioning value chain. Poor communication has been identified as a major reason for food loss in the avocado value chain of Meru County, Kenya (Bouma, 2024). Research shows that an estimated 35% of avocadoes are lost before they reach the market or consumers because of inefficiencies in supply chains (Snel et al., 2021). The losses occur because of fragmented communication and limited information flow amongst the stakeholders within the value chain, resulting in interlinked problems.

In Meru County, the three farmers' cooperatives working towards bridging the communication gaps in the chain are Mt. Kenya Avocado Farmers' Cooperative Society, Mt. Kenya East Avocado Farmers' Cooperative Society, Abothuguchi Avocado Farmers' Cooperative Society (NFP Connects, 2022). To address their challenges, this research aimed to assess the specific needs of the farmer cooperative in terms of functionalities for an Information and Communication Technology solution and to develop an action plan that will facilitate improved communication and coordination within the avocado cooperatives in Meru County in coming years.

Information and communication technology: ICT infrastructure and existing ICT solutions

The agricultural industry is experiencing a transformation driven by increased adoption of technology on different frontiers. Through the digitisation of agriculture, farmers enjoy superior seed quality, access markets, accurately predict the weather, and monitor product distribution.

ICTs are technologies that facilitate communication and enable the processing and transmission of information electronically. ICTs include contemporary social networking, reading and writing interfaces on the web, file sharing online, and policies and laws governing the transfer of media and devices (Yakubu et al., 2013a). It is an avenue for bridging communication gaps among stakeholders in the value chain through a network called the "Research-Extension-Farmer-Inputs-Linkage System (REFILS)" (Yakubu et al., 2013b).

ICT infrastructure comprises the interconnected network of hardware, software, networking devices, data storage, security and services that enable an organization to function efficiently (Afriyie, 2012; Čolaković and Hadžialić, 2018).

Kenya is a forerunner within Africa in the use of information and communication technologies (ICTs) and has more digital-for-agriculture (D4Ag) enterprises and users than any other country in Sub-Saharan Africa, with over 100 solutions on the market (Meza, Hansen, and Osgood, 2008; Bolwig et al., 2021). These existing solutions include:

1. The mobile money platform (M-PESA and Kilimo) widely used for financial transactions within the country.
2. Kenya Agricultural & Livestock Research Organisation (KALRO) offers several resources and mobile applications focused on various agricultural topics including apps on banana, garlic, cassava, maize, and avocado to help farmers make informed choices. KALRO's mission is to digitise the agricultural value chain (KALRO, 2021a).
   KALRO offers two mobile applications specifically designed to assist avocado farmers.
   - KALRO Avocado Seedling App provides users with information on avocado varieties suitable in Kenya, alongside guidance on seedling multiplication (KALRO, 2021b).
   - KALRO Avocado Varieties provides users with information on the 40 varieties. Out of the 40 varieties of Avocado, Hass is the main export variety and Fuerte is preferred for processing (KALRO, 2021b).
3. eProd Solutions cater to larger agribusinesses using Enterprise Resource Planning (ERP) Systems to manage inventory, track orders, and improve overall supply chain efficiency. Their solution comprises tools that streamline processes, ensuring seamless collaboration with thousands of suppliers from procurement to distribution and managing farmer networks, from registration to field monitoring to payment processing. It manages input distribution, loans to farmers and their repayments, monitors and evaluates the performance of farmers, providing feedback and incentives to improve their productivity and produce quality. It has an inbuilt end-to-end traceability and mapping tools (GPS, Polygons) that allow geotagging to verify the location and origin of your products while enhancing transparency and traceability (eProd Solutions, 2024).
4. Pharox Logistics Intelligence is centered on a seamless logistics chain and processes that are achievable with technology (Pharox Logistics Intelligence, 2024). They have several options:
   - **U-POD**: A mobile app solution that digitizes the value chain in real-time for effectiveness and efficiency. It shares logistics information and automatically alerts all trip deviations.
   - **SMART MOVE**: It provides visibility and integrity of shipment/assets. It has features such as seamless condition monitoring before, during, and after trips, workflow automation, and auto-billing (Pharox Logistics Intelligence, 2024).

Research objectives

The objective of this research was to develop an action plan for implementing an ICT application to improve communication and coordination within the farmer cooperatives in Meru County. To support this objective, it also aimed to proffer answers to the following:

a. The communication and coordination needs of the farmer cooperatives in Meru County solvable with an ICT application.
b. The functionalities of the ICT application that will address the needs of the farmer cooperatives.
c. The key steps and timeframe for developing the application.
d. The resources needed in developing the application and implementing the action plan.

The intended outcomes of this research were an advice to the cooperatives and commissioner on the functionalities of an ICT application in the short-term and the long-term, as well as an action plan for strengthening communication and coordination using an ICT application.

Methodology

This study was carried out in Meru County located in east-central Kenya, investigating two avocado farmer cooperatives societies—Mount Kenya Cooperative Society and Abothuguchi Cooperative Society—using a qualitative approach.

For this research, a social constructivist approach was selected as it allowed in-depth investigation. Two data types were collected for this research:

- **Secondary Data**: A desk study was conducted to gather secondary information on the background information on avocado, communication, and governance structure in the county, understanding of ICT functionalities and components, existing ICT solutions in the county, key steps and timeframe for developing the application and potential ICT application using Google Scholar, ScienceDirect, and previous thesis on Greeni.
- **Primary Data** utilizing semi-structured interviews and focus group discussions with the farmer cooperative, app developer, KALRO, Pharox and eProd Solutions to gain insight into the existing functionalities, shared experiences, identification of the specific needs, and the possibilities for the farmer cooperatives.

The research utilized purposive sampling to identify the stakeholders to be interviewed because of their partnerships with the FORQLAB Project, potential support to the avocado value chain, the existing ICT applications and solutions for the chain (*Table 1 and 2)*.

Table 1: Summary of Research Approach

RESEARCH QUESTIONS	RESPONDENTS	METHOD
What are the communication and coordination needs of the farmer cooperatives in Meru County solvable with an ICT application?	• Farmer Cooperatives	Focus Group Discussion
What are necessary functionalities of the ICT application that will address the needs of farmer cooperatives?	• Farmer Cooperatives • eProd Solutions • App Developer • KALRO	Focus Group Discussion with cooperatives Interviews with eProd, developer, and KALRO
What are key steps and timeframe are for developing the application?	• App Developer • eProd Solutions • KALRO • Pharox	Interviews Desk Research
What are the needed resources in developing the application and implementing the action plan?	• App Developer • eProd Solutions • KALRO • Pharox	Interviews

Table 2: Sampling Overview

STAKEHOLDERS	RESPONDENT	SIZE	TOOL	SAMPLING METHOD
Farmers' Cooperative	Mt. Kenya Cooperative	6 cooperative members	FGD	Purposive Sampling of Cooperatives Random Sampling of Participants
	Abothuguchi Cooperative	6 cooperative members		
eProd Solutions	Founder/CEO of eProd Solutions	1	Interviews	Purposive Sampling
App Developer	Junior Researcher with FORQLAB Project	1		

KALRO	ICT Officer	1		
Pharox Logistics	Director of Pharox	1		

For assessing the ICT functionalities and to develop an action plan, a conceptual framework was used that outlines the linkages amongst the three main sections: Needs Assessment, ICT Functionalities, and Development Plan highlighting short-term and long-term functionalities related to information sharing and analytics, access to market and finance, data management, and traceability as key services provided by ICT-for-agriculture solutions (Feed the Future Policy Brief, 2018).

For the analysis, thematic analysis was employed and presented in a Microsoft Excel Sheet. Further analysis was conducted using:

- P.E.S.T.E.C Analysis to consider the factors that are conducive to strengthening the implementation of the ICT application.
- S.W.O.T. Matrix assesses the current ICT infrastructure of the cooperatives, identifies areas for improvement, and explores opportunities for new solutions.

Findings

This research investigated the needs of the farmer cooperatives in Meru County.
However, in understanding their needs, there is a need to understand the underlying challenges the farmers are facing, which requires the necessity of this research. From the focus group discussions with Mount Kenya and Abothuguchi farmer cooperatives, the study revealed that the challenges of the farmer cooperatives are inclusive but not limited to the following:

- Limited reach: Some of the farmers do not have smartphones, which limits their access to information and resources.
- Break in communication of urgent information from extension officers to cooperative executives and from the cooperatives executives to farmers.
- Lack of a centralised system for communicating and educating
- Lack of a feedback mechanism.
- Farmers are not always readily available for new information and implementation. It takes time to adopt new initiatives.
- Current communication methods are slow, expensive, and unreliable.
- Digital literacy: Farmers need training to utilise digital devices effectively.
- Need for Real-Time Communication: A system for instant messaging to all members is essential.

The cooperative members attributed the digital divide—the absence of smartphones—amongst some farmers as a primary obstacle to timely communication, particularly from cooperative executives to farmer members. Because of this disparity, urgent updates on best agricultural practices, pests and disease control, market trends, and prices are often delayed or undelivered altogether.
Upon analysing the challenges the farmer cooperatives are facing, the needs assessment from the focus group discussions with the farmer cooperatives revealed that these needs are grouped into the following functionalities:

1. Data Management Functionality**:** A website for the cooperative with members' login profiles that allows for a comprehensive member database including biodata, number of trees owned, land size and location, production history of individual farmers, sales, and inventory management. It also should have a feature for predicting or forecasting yields for future harvests.
2. Market Data Functionality**:** This provides farmers with real-time market data on market opening/closing periods, available markets, and price trends, allowing room for generating market data reports seamlessly.
3. Support or Educational Service Functionality**:** This allows adequate record keeping of support services to individual farmers on sustainable agricultural practices and provides a training feature for knowledge sharing. It should include a comprehensive production/husbandry information section on avocado management practices.

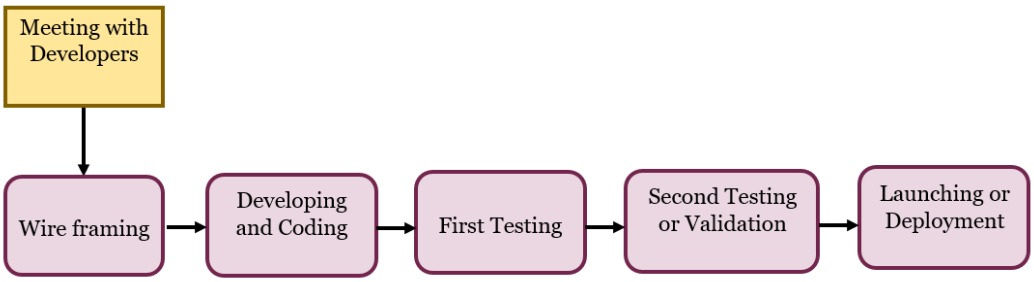
4. Financials Functionality**:** Allows record keeping on sales prices, profits, market prices, and loans/credit obtained specifically on each farmer's dashboard.
5. Traceability Functionality**:** Allows detailed tracking of avocadoes from a specific origin to the destination market.
6. E-commerce Functionality**:** An online marketplace for selling and buying avocadoes for the best prices. It allows transparency and prevents farmers from being exploited by brokers.

The interviews with ICT experts from KALRO, Pharox, and eProd Solutions revealed that the following aspects make an application user-friendly:

- A user interface designed from customer experience with simplicity and easy accessibility. It should be designed with visual elements such as colours and icons that appeal to users.
- Availability of application on single and multi-app platforms/operating systems i.e. Android and iOS.
- Compatibility of the application with mobile and web platforms with seamless user experience, based on user preference.
- It must be designed with simple language.
- The IT system should support existing processes rather than dictating them and its goal is to enhance users' operations.

It was also found that the development of an application requires the key steps (Figure 1).

Figure 1: Developmental Steps of an Application



Source: Author's Compilation from Interview with KALRO ICT Expert (Kimani, 2024).

Besides, resources such as financial resources, human resources, technical resources, and infrastructure are needed. The findings indicated necessary funding ranging from KSh367,252 to KSh600,000 from cooperatives, government agencies, private investors, or developmental organisations. Furthermore, factors were found that influence the implementation of an ICT application within the avocado cooperatives (*Table 3)*.

Table 3: P.E.S.T.E.C. Analysis of Influencing Factors for Strengthening ICT Implementation

FACTORS	RESULTING IMPACT
Political	▪ Encouraging governmental support and investment towards ICT implementation such as the KALRO apps for diverse value chains. ▪ Stable political environment in Kenya for developmental organizations to invest and for the successful adoption of ICT. ▪ Supportive regulations regarding data privacy and cybersecurity.
Economic	▪ Struggling financial capacity of the farmers to afford the associated costs of the application. ▪ Growing economy of the country. ▪ The presence of reliable and quality internet connectivity and electric supply, albeit unaffordable for some low-income class. ▪ Increased international demand for Kenyan avocadoes determine the need for a transparent application.

Social	▪ Some farmers are resistant towards change and technology. ▪ Digital illiteracy especially with old-time farmers. ▪ Minimally strong social networks of farmers on knowledge sharing and technical support on their farms.
Technological	▪ The availability, although limited affordability of mobile devices and software. ▪ High subscription costs/pricing model of such an application. ▪ Digital illiteracy.
Environmental	▪ Varying climatic changes in counties and resultant effects of the pests such as False Codling Moth (FCM) especially in the warmer counties. ▪ An application centered on promoting sustainable practices already existing like the KALRO apps.
Cultural	▪ The priority of a cultural appropriate app by the developers. For instance, the KALRO apps are designed in major languages of English and Swahili, and also transited into other county languages of Kenya for easy user accessibility. ▪ Conflicting beliefs and values of the avocado farmers.

The S.W.O.T. analysis (*Table 4)* provides an overview of the current ICT infrastructure and its impact on the Meru County avocado farmer cooperatives. The key findings showed that while there are opportunities for improved communication, efficiency, and traceability, challenges relating to digital literacy, infrastructure, and trust must be addressed to ensure the successful integration of the application within the cooperatives.

Table 4: S.W.O.T. Matrix of the Farmer Cooperatives ICT Infrastructure

STRENGTHS	**WEAKNESSES**
▪ Existing ICT Infrastructure: KALRO avocado app, mobile devices, internet connectivity. ▪ High cooperative power within the farmer cooperatives. ▪ Successful ICT initiatives such as MPESA, eProd ERP app, and Pharox's U-Pod.	▪ Low level of digital literacy/lack of technical skills in accessing applications amidst old farmers. ▪ Infrastructural gaps. ▪ Financial constraints by farmers for the application. ▪ Lack of trust amongst farmers.
OPPORTUNITIES	**THREAT**
▪ Better communication and transparency amongst the avocado value chain stakeholders. ▪ Efficiency in operations and reduced costs of operations. ▪ Traceability and tracking of produce in real-time. ▪ Market accessibility and price transparency. ▪ Knowledge sharing and capacity building.	▪ Disruptions or failures in application resulting from infrastructural challenges such as internet connectivity or electric supply in remote areas. ▪ Redundancy of the app usage by users due to digital illiteracy or unwillingness to adopt. ▪ Cybersecurity risk.

Conclusions

From the findings, developing an application is crucial to enhance communication and coordination within the avocado farmer cooperatives in Meru County. It highlighted the following considerations while developing an application:

- Understanding the specific needs of the farmer cooperatives.
- Designing a simple and user-friendly interface.
- Integrating expert knowledge and user preferences.
- Training and capacity building for farmers in digital skills.
- Affordability and accessibility of the solution.

It also highlighted that an ICT application could help address these communication and coordination challenges by: Facilitating efficient data generation and retrieval, Improving system performance through data-driven decision-making, Ensuring accurate data collection and analysis, Supporting forecasting for system improvement, Documenting and storing the education days, Centralising operations and reducing information transmission time.

In conclusion, the action plan for developing and implementing an application that improves communication within the farmer cooperative involves *(Table 5)*:
(a) background research and problem identification, (b) needs assessment, (c) choosing developing organisation and securing funding, (d) prioritizing functionalities, (e) recruitment of personnel, (f) acquisition of infrastructure), (g) designing and developing the application, (h) training, (i) deployment and implementation, and (j) monitoring and evaluation.
While there are opportunities for improved communication and efficiency, challenges related to digital literacy, infrastructure, and trust must be addressed first to ensure the successful integration of the application within the cooperatives.

Recommendations
To leverage the potential of this application, the recommendations – shown in a theory of change (*Figure 6*) - are put forward to the FORQLAB Project and the Meru County Avocado Cooperatives as intervention points for improved communication.

Recommendation 1: Enhancing Technical Capacities and Digital Literacy
Implementing an application within the cooperatives presents the medium to enhance communication and collaboration. However, successful adoption and utilisation depend on the users' technical capabilities and digital literacy.
It is important to raise awareness and improve the skills of farmers so that they can understand how to use the application effectively. It involves considering their education and digital literacy levels when designing training programmes and incorporating user information into the application. To increase farmer participation, the first step is to raise awareness among young and middle-aged farmers about available services. It is advisable to introduce older farmers to ICT networks at a later stage. Investing in the training programmes empowers and fosters a culture of continuous learning within the cooperatives.

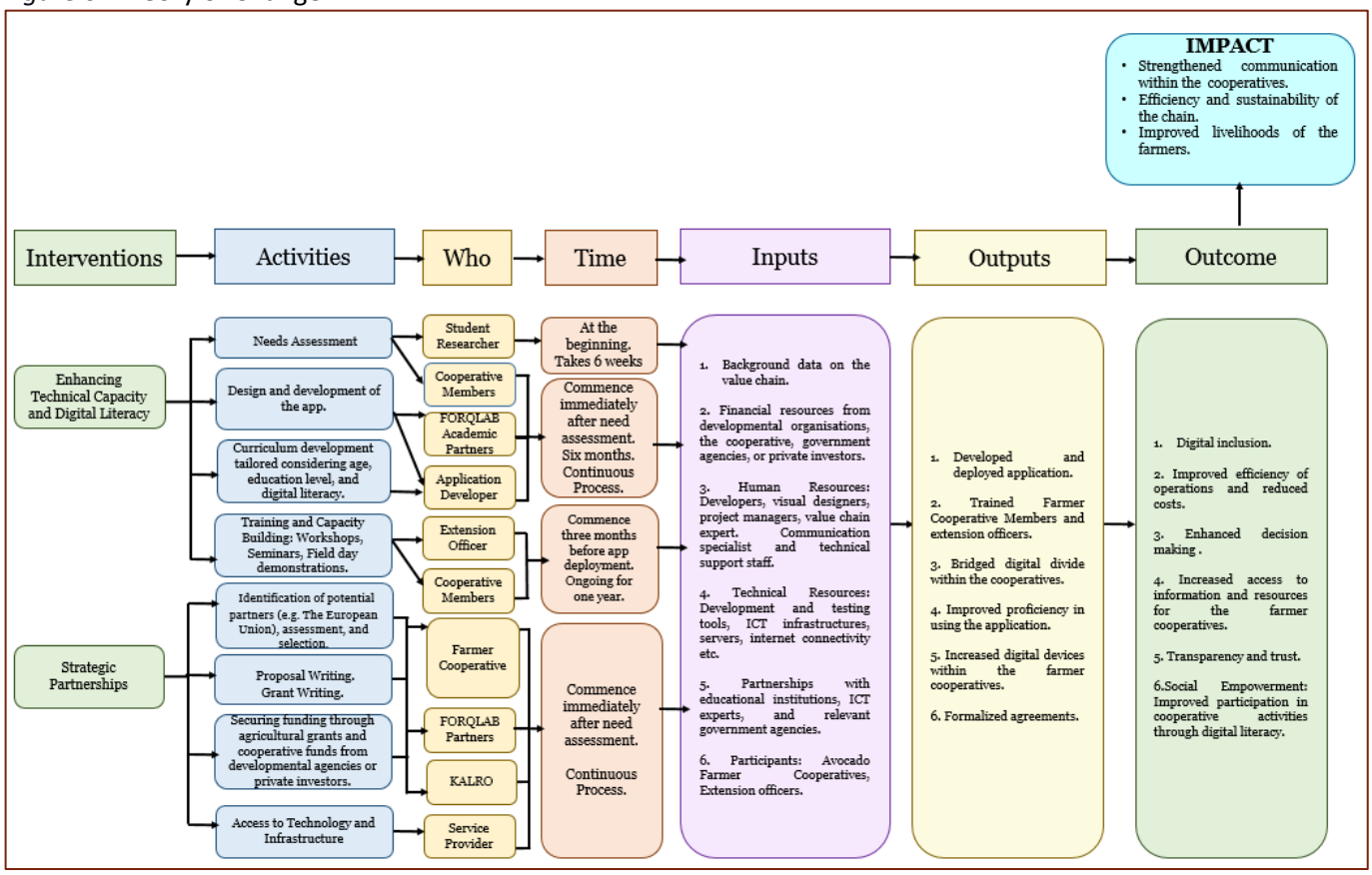
Recommendation 2: Building Strategic Partnerships
The development of an application requires significant resources. Building strategic partnerships with various stakeholders can provide the funding and resources to support. Partnerships with:

1. Government Agencies: For example, KALRO's connections/access to the developmental organisations that support agricultural development initiatives. Also, engagement with the local county and the national government provides access to subsidies, grants and technical assistance, particularly for a high-export crop like avocado.
2. Private Sector Investment: Partnerships with technology companies such as eProd Solution, Pharox, Digifarm, venture capital firms, and Safaricom can provide access to financial resources, technical expertise or market access.
3. Donor Organisations: Identifying donors with a focus on agricultural development and sustainability such as from foundations or non-governmental organisations can increase chances of securing financial assistance through grant or proposal writing.
4. Cooperative Partnerships: Joint pooling of resources and expertise amongst the avocado cooperatives in the country.
5. Research Institutions: Collaborating with private research institutes/universities can provide access to human resources and infrastructure for development.

Table 5: Action Plan for the Implementation of the Application

PHASES	ACTIVITIES	WHO	WHEN
One: Problem Identification And Needs Assessment	▪ Background research on the value chain ▪ Initial meeting with farmer cooperatives, needs assessment. ▪ Identification and prioritization of the functionalities to be included in the application.	▪ Student Researchers ▪ Farmer cooperatives ▪ FORQLAB Academic Partners ▪ Developing organisations	In the beginning. Timeline of six weeks.
Two: Funding And Partnerships	▪ Identification of potential partners, assessment, and selection. ▪ Preparation of grant proposals. ▪ Evaluation of proposals. ▪ Application for subsidies or cooperative funds. ▪ Securing funding through agricultural grants and cooperative funds.	▪ Student Researchers ▪ FORQLAB Academic partners ▪ Development partners	Commences during needs assessment. It is a continuous process.
Three: Resources Acquisition	▪ Recruiting human resources: Developers, visual designers, project managers, value chain experts, communication specialist and technical support staff. ▪ Acquisition of technical Resources: Development and testing tools, ICT infrastructures, servers, internet connectivity etc.	▪ Farmer cooperatives ▪ FORQLAB Academic partners ▪ Development partners.	Commences once funding is secured. It is a continuous process.
Four: Application Development	▪ Prioritization of functionalities. ▪ Identification of the appropriate design based on available resources and infrastructure. ▪ The development of the application.	▪ Application Developer ▪ Developmental funders ▪ Project manager ▪ Value chain experts ▪ Project manager ▪ Value chain experts	Within six months of the needs assessment phase.
Five: Training And Capacity Building	▪ Curriculum development tailored to age, education, and digital literacy levels. ▪ Awareness training ▪ Application Training. ▪ Quarterly knowledge sharing events using field days demonstrations.	▪ Farmer cooperatives ▪ Extension officers ▪ FORQLAB academic partners ▪ Meru County Government.	Commence three months before application deployment. It should run monthly per cooperative with quarterly rotations continually for one year.
SIX: Implementation, Deployment, And Monitoring	▪ Implementation and deployment of the application for utilisation within the cooperatives. ▪ Monitoring and evaluation. ▪ Maintenance of the application.	▪ Application developer ▪ Extension officers, FORQLAB academic partners ▪ Government of Kenya.	Immediately upon launch and quarterly evaluation.

Figure 6: Theory of Change



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Leveraging Information and Communication Technology (ICT) application to enhance Communication and Coordination within Nandi Avocado Farmers Cooperative Society

Mercy Moraa Mairura, Albertien Kijne, Marco Verschuur

Practice Brief
FORQLAB Project 2024-03

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

van hall larenstein
university of applied sciences

Introduction

According to Kourgialas and Dokou (2021), avocados have seen an increase in production and consumption in recent years, as well as a steady increase in their market share worldwide. This indicates that the avocado market has a lot of potential, and it is important to capitalize on the diverse markets.

Figure 1: Location of Nandi County within Kenya

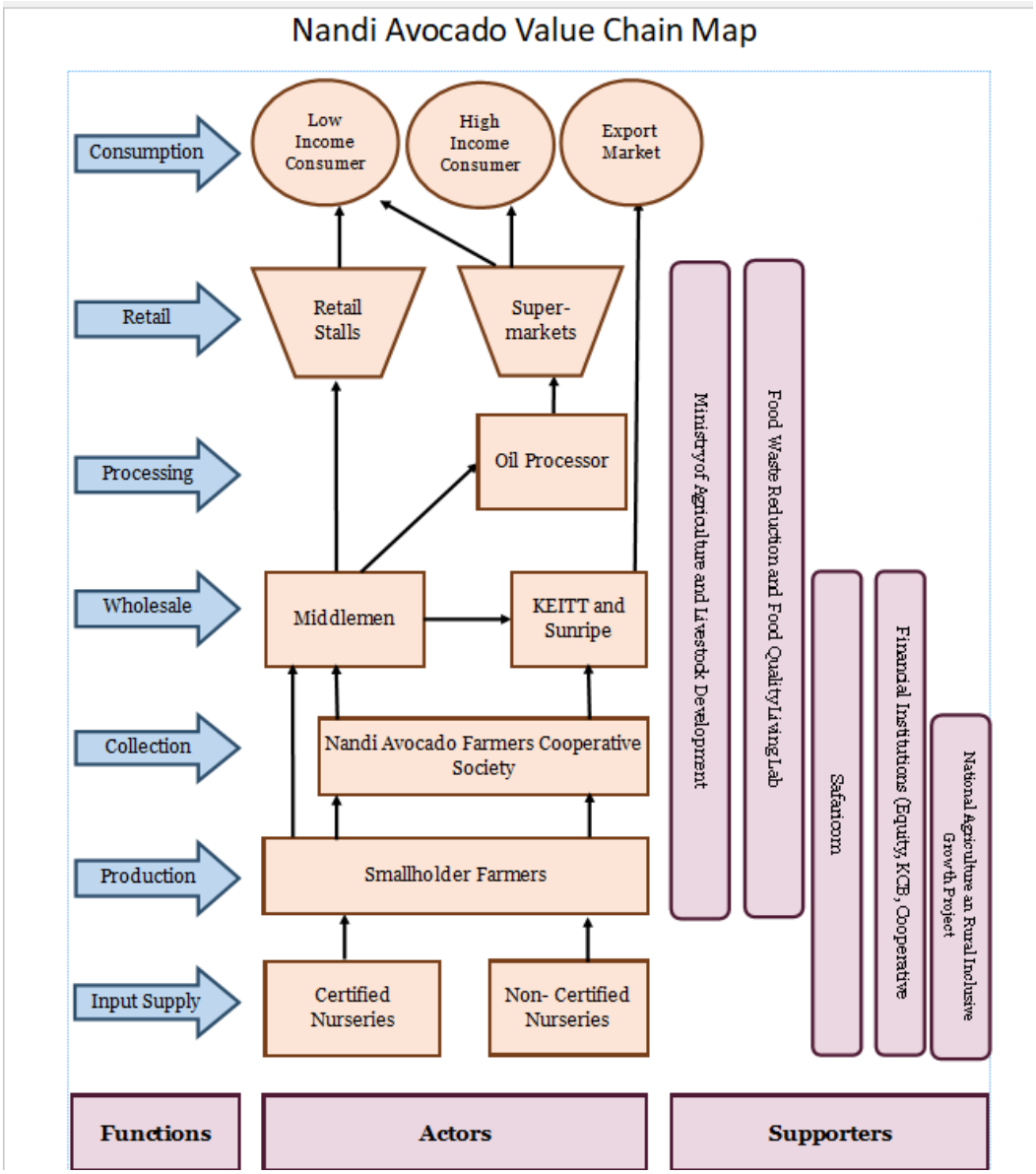
(Source: Maphill 2013 and Adobe Stock, 2024)

This study investigated levering information and communication technology (ICT) for the Nandi Avocado Farmers' Cooperative Society in Nandi County. Nandi County is in Kenya's North Rift region and has multiple constituencies (Figure 1).
To capitalise on the potential of the avocado market, chain actors must coordinate and communicate effectively with one another as the market grows. Figure 2 depicts the various stakeholders involved in the Nandi avocado value chain.

Applications are currently available in Kenya to provide farmers with information on market prices and weather trends. There are apps like KALRO Selector, which advises farmers on what kind of crops to plant or livestock to keep, KALRO KAOP, which provides weather patterns information, and KAMIS, which provides information on commodity pricing in various counties. Additionally, farmers can learn about the types of seedlings that are accessible and agricultural procedures by using the KALRO Avocado seedling, KALRO Avocado variety, and KALRO GAPs applications (Kenya Agricultural & Livestock Research Organization, 2024).

Literature has demonstrated that communication is essential to organizational governance (Peng, Hendrikse, and Deng, 2018). By fostering cooperation and communication and expanding their network of future networks, information and communication technologies (ICTs) have the power to transform cooperative cultures. Information and communication technologies (ICTs) also advance cooperative management by strengthening data and operational management practices. It is impossible to overstate the value of cooperation and communication inside a company.

Figure 2: Nandi county avocado value chain map



According to studies, the cooperatives don't have a strategic plan or key indicators for managing their finances and operations. The challenge of effective communication stems from the fact that Nandi farmers' cooperatives still need to improve their ability to communicate about production practices, market information, extension services, partnering with certified seedling suppliers, and supporting farmers' certification. Nevertheless, cooperatives play a crucial role in advocating for the interests of farmers (Bouma, 2024).

The absence of a well-organized framework and sufficient data administration has led to issues including mismatches in supply and demand, challenges in accurately recording supply, and the cooperatives' incapacity to clearly state their goals and demands in terms of value addition.
This study assessed the key requirements needed to successfully implement an ICT application to strengthen communication and coordination within Kenya's Nandi avocado farmers' cooperatives.

Methodology

The research utilized qualitative data collection tools, semi-structured interviews and focus group discussions to gather in depth stakeholder opinions. Respondents for the interviews were selected

based on their expert knowledge of ICT applications and development and focus group discussion participants were selected through purposive sampling. The two focus group discussions involved 6 people each, one with the management of the Nandi cooperative team and the other with farmers.

The following five stakeholders were selected to be interviewed by semi-structured interviews as they are important sources about ICT applications and development that can be useful for Nandi Avocado Farmers Cooperative Society and their members.

- KALRO has also already developed several applications, therefore they have a wealth of knowledge on app creation. The KALRO applications offer insights to farmers on inputs, GAPs, and weather practices (Innovation Platform Agribusiness Portal, 2017).
- Amtech software developer was chosen since the cooperative has just begun using the Easy Pro program.
- eProd Solutions already has supply chain applications that might be incorporated into the Nandi avocado value chain thus their input was taken on board. The applications of eProd Solutions support supply chain management, coordination of logistics and traceability for small and medium enterprises.
- Pharox may also be a supporter in the future since it is great at logistics planning and tracking and traceability of products.
- A junior researcher from the FORQLAB project already designed basic features for the proposed application.

See table 1 for details about the research questions and in what way they were answered.

TABLE 1: RESEARCH PARTICIPANTS

Research questions	**Respondents**	**Sampling**	**Collection Tools**
What are the farmers' and cooperative communication and coordination needs in Nandi County?	• Farmers • Nandi Cooperative	Purposive sampling	Focus Group Discussion Desk study
What short and long-term functionalities should the proposed ICT application have?	• Farmers • Nandi Cooperative • FORQLAB Junior Researcher • KALRO • eProd Solutions	Purposive sampling	Focus Group Discussion Semi-structured Interviews Desk study
What resources are needed by developers to develop the proposed application?	• eProd Solutions • KALRO • FORQLAB Junior Researcher • Pharox • Amtech EasyPro software developer	Purposive sampling	Semi-structured Interviews
What are the key steps and timeframe needed to develop the proposed application?	• eProd Solutions • KALRO • FORQLAB Junior Researcher • Pharox • Amtech EasyPro software developer	Purposive sampling	Semi-structured Interviews

Findings

According to the cooperative and farmers, WhatsApp and bundled SMS are currently the cooperative's methods of communication with farmers. However, not every farmer has an Android phone, and not every farmer checks their phone frequently for the bundled SMS.

The cooperative indicated that to spark farmers' curiosity and encourage a response, bundled SMS messages bearing the sender ID "Nandi Avocado Farmers' Cooperative" need to be sent to them. It was also found that harvesting schedule is lacking, and that the poor quality of the road network and inclement weather make it difficult for cooperatives to coordinate their transportation.
Hard copies of the farmers' information, including the quantity, quality, and payment amount, have been kept by the cooperative. Nevertheless, they have only recently started utilizing Amtech's EasyPro software. EasyPro was made possible by the World Bank through the NARIGP initiative, and this year's cost of accessing the website has been paid for. The webpage is only accessible to board members. The database contains a list of all the cooperative members, the quantity of produce each one has supplied, the amount each has been paid, and the amount the farmers are still owed.

To learn more about farming, the farmers from the focus group discussion use applications like Digifarm; they prefer this platform since it features a chatbot that lets them ask questions and receive responses. Since KALRO applications offer the best farming information and are efficient, they also utilize them for their other crops and livestock. The farmers in the focus group discussion commented that some farmers are either unaware of or uninterested in the apps that are now available.

During the focus group discussion, the farmers addressed the following needs:

- Free soil testing services
- Marketing prices for Hass and Fuerte with weekly updates
- Financial statements showing the cooperative's performance
- Knowledge of applying chemicals to avocados
- Avocado collection scheduling
- A chat platform
- Certified seed supplier information
- Information on GAPs
- Weather data
- Hailstone insurance
- Financial details on loan eligibility

The farmers recommended that the application be made available in English since it is an easier language to understand compared to Kiswahili and Kalenjin, and 70% of cooperative farmers have access to smartphones. Additionally, free access to the suggested app is essential, as well as app awareness and training.

During the focus group discussion, the cooperative management team brought to attention the following needs:

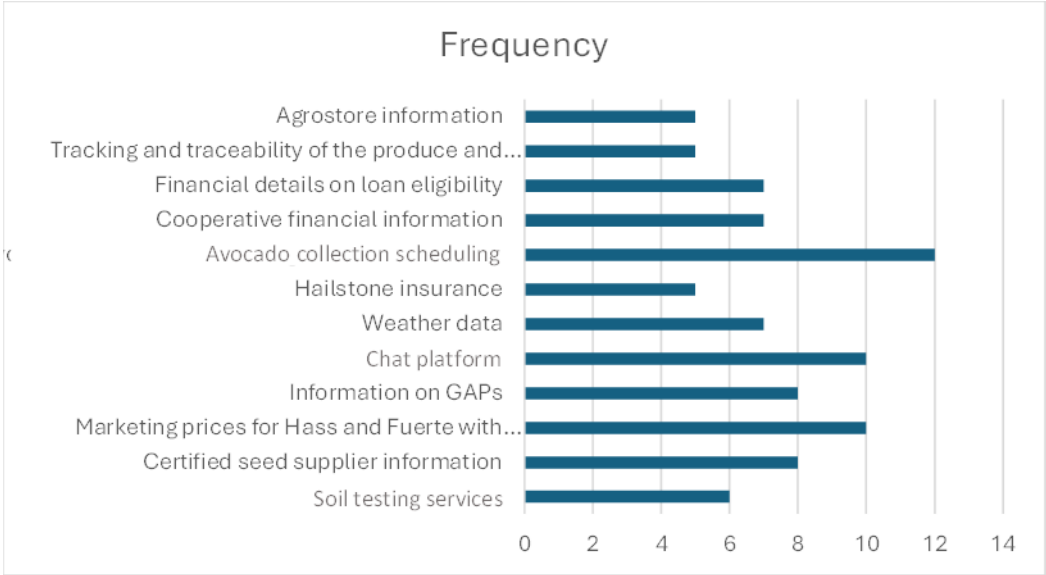
- Unlimited SMS and the "Nandi Avocado Farmers' Cooperative" heading must be included in the Sender ID
- Tracking and traceability of the produce and the GPS coordinates of the farmers
- Guidelines for purchasing items from the agro store (inputs like fertilizers, fruitfly, and false codling moth traps)
- Uploading and downloading documents (cooperative newsletter, latest GAP training information, trends in production)
- Contact details with photos of the cooperative board members so that farmers can identify them.
- Weather data
- A chatbot or chat platform
- Certified seed supplier information
- Applying for cooperative shares
- Marketing information with national and global prices
- A digital weighing scale that is integrated with the app

- The cooperative's financial information
- Agro-store information to know what the store has
- Information on GAPs
- Production schedules
- Loan accessibility
- Avocado dispatch details

Furthermore, the management of the cooperative suggested making the application available on computers and laptops in addition to phones.

Figure 3 shows the frequency of how often the needs were mentioned by the persons that took part in the two farmer group discussions, one with farmers (6 persons) and one with the cooperative management (6 persons).

Figure 3: Frequency of the Farmers' and the Cooperative needs



The different needs as found in this research are all associated with the five essential IVT services that are stated by Agrilinks (2018): information analytics, tracking and traceability, market and financial accessibility, and information sharing.
Given that information sharing will help farmers satisfy their demands, it is a necessary service. Farmers' needs are further met by providing timely, accurate, and relevant information so that they may make educated decisions. Their agricultural output and income can be significantly increased as a result.

The chat function, which would facilitate communication between the farmers and the cooperative, was one of the most often mentioned features. It was also mentioned that forums and videos may be added in the future. The cooperative could establish a website with a chatbot so that farmers can ask and receive inquiries from the cooperative, in addition to setting up toll-free lines for communication with farmers.

The interviews with the stakeholders also revealed that for developers to create an application, they must first ascertain what the user's needs are, then put together a technical team that can meet those demands, and secure funding for the application. Funding for the application may be provided by the government or potential development partners. In addition, hardware infrastructure such as phones, laptops, printers, and an internet connection are required.

According to the study, creating an application takes three to six months. The following are the key steps involved in creating an application:

- Planning and determining whether they have the necessary content for the application
- Designing of the application
- Developing the wireframe (blueprint or visual guide that outlines the basic structure of the application) and then coding the wireframe begins
- Testing of the application, it is done by the developers and a few users to ensure that it functions as intended then it is deployed (moving app from developing environment to server) and launched (officially introduced to users).

After the application is launched the developers can monitor and see who is downloading the apps and make sure they are being properly utilized. The application then needs to be improved in terms of performance and user-friendliness to continue meeting customers' expectations.

The SWOT method was used to analyse both the internal and external environment of the Nandi avocado value chain (Table 1).

Table 2: SWOT For Nandi Avocado Value Chain

Strengths • The cooperative has an in-house extensionist. • Farmers use organic production methods. • Use of other phone applications by farmers like Digi-farm and the KALRO applications. • Partnership by World Bank with cooperative on the Easypro program. • Presence of TOTs in wards. • Acquisition of Export license by cooperative. • Certified seedling suppliers (Ustawi Limited).	**Weaknesses** • Cooperative lacks aggregation centres. • Cooperative lacks product traceability. • There is poor coordination during the collection of harvest.
Opportunities • Building of a packhouse • Availability of supporting partners like Agriterra • Training farmers on Global GAP standards • Market accessibility in Belgium	**Threats** • The hailstones damage the avocado trees • There are poor roads

Conclusions

The study revealed that while the Nandi cooperative already has the Easy Pro program and can incorporate the needs of the farmers and cooperative. Implementing an ICT application is currently not viable. Nandi Cooperative needs to arrange their data and ensure that all of their internal data is traceable and can be transparently evaluated. This will assist in eliminating the discrepancy between supply and demand. However, the Easy Pro program was only paid for until December thus, the program's financial sustainability is required.

Furthermore, KALRO applications provide information on GAPs and weather trends. Farmers need to be informed about the existing applications and encourage their adoption through targeted awareness campaigns and training.

According to the study, the cooperative can enhance coordination and communication between the farmers and the cooperative by using bulk SMS with their sender ID. Moreover, the cooperative can use the toll-free numbers and create its website.

An application to improve coordination and communication amongst the four FORQLAB avocado cooperatives (Mt. Kenya, Abothoguchi, Mt. Kenya East, and Nandi) may be required in the future. The cooperatives would be able to share their experiences and interact efficiently. If such an application is created and put into use, it may eventually improve cooperatives' overall efficiency throughout the avocado value chain by fostering cooperation, knowledge exchange, and decision-making.

If the application is developed, a budget of Ksh. 562,685 (3,935 euros) is anticipated for the development of the application by eProd for the Nandi Cooperative, which includes customized training for a maximum of 1,000 farmers (VAT excluded). Furthermore, each farmer would pay a yearly subscription fee of Ksh. 154,000 (1,100 euros) for the application. Comparatively, Ksh. 600,000 (4,196 euros) is the anticipated budget for creating KALRO applications.

Conversations with the cooperative and farmers revealed that this initiative would require a significant financial commitment, for which external support would be essential. According to the study, funding for applications usually comes from the government, investors, developing partners, and value chain actors.

Moreover, although KALRO programs are available for free download, adoption rates are still low among farmers. If there was a usage fee, farmers could be even less motivated to utilize the application.

Recommendations

Given that it is currently not feasible to develop and install a new ICT application, the following recommendations were given to Nandi Cooperative.

- Streamlining Cooperative operations
  Prioritizing the "Nandi Avocado Farmers' Cooperative" bulk SMS header registration during the next three months will enable the cooperative to efficiently inform farmers about harvest collection schedules. To set up the Sender ID, the cooperative needs to speak with Safaricom or Airtel's telecommunication services. They can also speak with them on the cooperative's toll-free number. The financial support can be provided by the FORQLAB project.
  In addition, the Cooperative needs to meet with the Amtech software developer and discuss how new features can be incorporated into the Amtech Easy Pro within three months to ensure proper data management and supply and demand alignment. By doing this, inconsistencies will be removed, and coordination will be improved overall.

  The cooperative can also meet with ICT personnel who will assist in developing their website. Both the website's funding and the expense of hiring ICT staff can be covered by the cooperative. The cooperative will be able to post about its activities on the website. Through the help of a chatbot the farmers and the cooperative communication can be made better.

- Forming strategic partnerships
  The study revealed that the Easy Pro program had only been funded till the end of the year; therefore, to obtain funding, the cooperative must form alliances with private funders within the next six months. Additionally, the cooperative can seek extended funding from the World Bank.

- Raising awareness of already-available apps
  The TOTs in the 25 wards can help raise awareness of Digifarm and KALRO programs. They can also train farmers on how to make the most of the applications.

The following are suggested if the new ICT application is to be created and used in the long term.

- Enhancing digital literacy

Educating and training farmers on the proper use of applications is necessary. The farmers can receive assistance in learning how to utilize programs from the cooperative management team, the application developer, and TOTs. To create an application that the farmers can fully utilize, the developers need to take into account the literacy levels of the farmers.

- Forming strategic partnerships
  The study indicated that the application would have a significant upfront cost, thus collaborations with the government, investors, development partners, and supporters in the avocado value chain are needed to secure funding. Furthermore, it is recommended that the cooperative pay the subscription cost to ascertain the sustainability payment of the application.

The theory of change for the recommendations in shown in table 2.

Table 2: Theory of change for proposed recommendations

Intervention	Activities	Input	Output	Outcome
Streamlining cooperative operations	Cooperatives using their sender ID in bulk SMS	Cooperative management team Telecommunication services	Farmers know the specific days their harvest is being collected	Reduction in post-harvest losses and proper coordination between farmers and cooperative
	More use of Amtech Easy Pro	Amtech software developer	Data management within the cooperative	
	Cooperative creating its website	ICT personnel	The members and partners access key information	Market itself to investors, and win new members thus promoting cooperative growth
Establishing tactical alliances	Securing funding for the Easy Pro program	Importers, exporters, World Bank and develop-ment partners contribute to the funding	The program cost paid and the program is running smoothly.	Improved data management, proper coordination, and communication between farmers and cooperative
Awareness creation	Creating awareness of the existing applications	ToTs Cooperative management team	Over 1000 farmers are aware and are trained on how to use the existing application.	Farmers have quality produce
Enhancing digital literacy	Farmers are trained on digital skills	Cooperative management team Application developer TOTs	Over 1000 farmers are equipped with digital literacy skills	Increased access to applications by farmers

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MODELING OF HANDLING AND TRANSPORTATION OF AVOCADO (*Persea americana)* FOR EXPORT FROM MERU COUNTY IN KENYA

Practice Brief
FORQLAB Project 2025-01

FORQLAB = Food Waste Reduction and Food Quality Living Lab in Kenya

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Introduction

Avocado (*Persea americana)* from Lauraceae family is divided into three sub-species that is Mexican (sub-tropical), Guatemalan (semi-tropical) and West Indian (tropical) (Griesbach, 2005). Avocado is thought to have originated from Central America mainly southern Mexico, (Araujo eta al., 2018). It is grown in many other parts of the world including, Southern America, Central Asia, South Africa and several other central African countries including Kenya (Schaffer et al., 2013). Avocado is thought to have been brought to Kenya in 1930s by the Portuguese and Commercial cultivation of avocado started in the 1960s and 23 tonnes of avocado were exported to Europe in 1970. Currently, avocado is produced in various agro-ecological zones of Kenya including Meru by small-scale growers (80%) and large-scale growers for subsistence, local markets and export (Horticultural Crop Development (HCD), 2020). Avocado production has gained popularity in Kenya competing with traditional crops like coffee and tea (Shivachi et al., 2023).

Challenges of avocado production and Marketing

Avocado production in Kenya is predominantly cultivated by smallholder farmers in different agro-ecological regions where Central and Eastern regions alone account for about 70% of total production (Muthee et al. 2023). Kenya has expanded production of avocado up to 80 percent particularly in rural areas and it is currently one of the top producers and exporters of avocados (Amare et al., 2019). While its export and domestic markets are significantly increasing, the sector faces challenges in European market access due to poor quality of produce (Lutta et al., 2024). Issues related to avocado losses have become a constraint in the avocado value chain. Post-harvest losses lead to pulp softening, rotting, physiological disturbances, and improper temperature management. Delgado *et al., (*2017) described how losses occur at different stages of product flow. The substantial postharvest losses occur during transit, mainly due to improper handling, transportation methods, and storage conditions. These losses are attributed by use of inappropriate containers of transport from farms to packhouses, failure to regulate temperature during transportation and overloading and this result in physical and mechanical injuries and subsequently untimely ripening causing numerous postharvest losses.

a. Use of inappropriate containers to transport avocado from the farm to pack houses.

Farmers in Kenya pack avocados in small containers during transportation from farm to pack houses resulting in overloading and eventual compression of fruits consequently resulting in internal damages.

b. Overloading of avocado during transportation

Overloading of avocado during transportation cause avocado Loss and waste in avocado supply chain management (Mazhar et al., 2024). Avocado fruits incur mechanical and chemical injuries during transportation from farm to pack houses. This is due to overloading and piling up of avocado in pickups. This leads to loss and waste of avocado.

c. Use of pickups and Lorries without packing them in creates during transportation

From farms to the pack houses, avocado fruits are transported in pickup loads that lead to application of weight on fruits placed at the bottom of the pick-up carriers leading to physical injuries of avocado contributing to avocado losses and waste. These losses are attributed to pulp softening, rotting and physiological disturbances.

d. Failure to control temperature during transportation

Transportation of avocados from the growing regions in Meru County to airport and eventually, to European supermarkets requires extensive logistical management (Bower and Cutting, 1987). Maintaining the cold chain is essential in avoiding soft fruit with physiological disorders (Cavuşoğlu et al., 2018). Failures to regulate temperature during transportation of avocado from farm to pack houses may lead to avocado losses. Most of the farmers in Kenya are using trucks that do not have temperature cooling systems to transport avocado from farm to pack houses thereby leading to waste.

However, there is little knowledge on the nature and impact of mechanical and physiological damages during transportation of avocados. Therefore, this project aims at establishing the impact and nature of mechanical and physiological damages of avocado during transportation.

Objective and justification

The general objective was to determine causes of losses in handling containers and transportation in export avocado value chain. And the specific objectives were to 1) determine the effect of overloading on the quality of export avocado fruit; 2) determine the effect of transportation temperature and containers/packaging on the quality of exported avocado fruit.

By minimizing losses, spoilage, and quality degradation, there is a direct impact on export volumes, increasing the tonnage of avocados exported. This, in turn, serves as a mitigation measure against any negative effects on the reputation of Meru avocados. Maintaining a positive image is vital for the global market perception of Meru-Kenya avocados, fostering a favourable impression and potentially opening new opportunities in international trade.

Furthermore, the positive impact extends to the country's balance of trade, as reduced post-harvest losses translate to increased foreign currency earnings. This economic benefit can contribute to overall national prosperity and sustainability. In essence, addressing post-harvest losses not only safeguards the income of local participants in the avocado value chain but also positions Meru-Kenya avocados as reliable and high-quality products in the competitive global market, ultimately benefiting the nation's economic health. This study contributes to positive change in food system outcomes.

Methodology

This study was conducted in two phases to evaluate the quality of *Hass* avocados following three different postharvest handling and storage conditions.

a. ***Netherlands:*** *Avocados that were harvested in Kenya ⟶ Transported to packhouses ⟶ chilled +shipped to Netherlands ⟶ Ripened ⟶ Analysed in Netherlands.*
b. ***Chilled:*** *Avocados that were harvested in Kenya ⟶ chilled ⟶ ripened ⟶ analysed in Kenya.*
c. ***Unchilled****: Avocados that were harvested in Kenya ⟶ ripened ⟶ analysed in Kenya.*

A. Phase One: Analysis in the **Netherlands**

The first phase was carried out in the Food Science Laboratory at Van Hall Larenstein University of Applied Sciences, Netherlands. A total of 45 *Hass* avocados, imported from Meru, Kenya, were collected from the Lidl warehouse in the Netherlands, 21 days after shipment. The fruits were then stored at room temperature conditions for five (5) days to allow for ripening. Thereafter, the ripened fruits were analysed over a five-day period for various quality parameters.

B. Phase Two: Analysis in Meru, Kenya

The second phase was conducted in the Food Science Laboratory at Meru University of Science and Technology. A total of 90 mature *Hass* avocados were harvested from a commercial farm in Meru County, Kenya and divided into two equal batches of 45 fruits each:

- **Batch 1 (Chilled)**: The fruits were subjected to cold storage (chilling) *at* 5^0C for 21 days, followed by five days of ripening at room temperature conditions. Subsequently, they were analysed over a five-day period.
- **Batch 2 (Unchilled)**: The fruits were stored at room temperature conditions for five days to ripen and were then analysed over a five-day period.

Each experimental treatment was replicated twice. The data collected were statistically analysed using the Least Significant Difference (LSD) test at a significance level of $p \leq 0.05$. The results are presented in tables for comparison. Parameters evaluated were a) Fruit firmness (texture analyser), b) Brix (refractometer), c) Oil content (Soxhlet method), d) Colour (calorimeter), e) Peroxide value (Titration) and f) shelf life ((photography).

a. Hass Firmness

Fruit Firmness was evaluated using a digital force gauge (Chatillon, DFE 100, Scientific Co., Chicago Il., USA) with a spherical tip 11 mm in diameter, which deformed the pulp up to 5 mm deep at a rate of 50 mm min-1. Five replications were taken with three readings in each experimental unit for four days. Firmness was expressed as the maximum compression force (N).

b. Hass Oil content

Oil content was determined using solvent extraction Soxhlet method (Fagundes et al., 2024). Three samples were taken per day to ensure accuracy.

c. Total soluble solid concentrate:

The total soluble solids were evaluated according to Terán-Erazo et al. (2019). A refractometer (300001, Sper Scientific) was used and drops of the pulp extract were placed in the prism. The results were expressed in °Brix. Five replications were taken with three reading in each experimental unit. Brix values (°Bx) were recorded for each sample daily.

d. Fruit colour

Fruit skin colours were measured with Calorimeter (Minolta CR-400 Corp, Ramsey, NJ, USA) with 8 mm diameter light path aperture. Individually fruits were measured in three parts around the equatorial axis. Two mean colour parameters reading were automatically calculated and recorded, L* value (lightness or brightness) and chroma (C*) taking into account a* (redness or greenness) and b* (yellowness or blueness). The value of hue angle (h0) and chroma (C*) was calculated from a*, b* and L*.

e. Peroxide Value

Peroxide values, indicating lipid oxidation, were measured using iodometric titration and expressed in mill equivalents of oxygen per kilogram (Meq/kg) of oil.

Results and discussion

Changes of Avocado Fruit Firmness during Ripening

Firmness is the resistance to penetration (Mbatchamen et al., 2024). Avocados analysed in Netherlands showed high level of firmness of 26.6N on 6th day and steadily decreased to 5.4N at the end of 10^{th}day. This result does not coincide with the research done by (Vázquez-López et al., 2022), which found that Hass avocado should reach ready to eat firmness of 4.4N. The fruit firmness decreased by 33, 49, 76 and 82% after 7^{th}, 8^{th}, 9^{th} and 10^{th} day after harvesting respectively. The result showed that chilling injury had effect on the avocado firmness. The decrease of firmness can be attributed to the activity of polygalacturonase (Magallanes-López *et al*., 2020) and pectin methylesterase (Defilippi *et al*., 2018). Pectin methylesterase removes methoxyl groups from the pectic constituents of the cell wall, which are subsequently depolymerized by polygalacturonase, reducing cell wall turgidity, structure, and composition (Uscanga-Sosa *et al*., 2019). Although firmness was maintained it hindered proper ripening and led to uneven texture and less desirable softness by the time of consumption in Netherlands. Chilled avocados had intermediate firmness of 20.76N and softened at slower rate reaching 5.2N on the 10^{th}day.

Table1: Changes in firmness level (N) of avocado fruits analysed in Netherlands (exported fruits) and in Kenya (chilled and unchilled).

Samples	Days after Ripening				
	Day 6	**Day 7**	**Day 8**	**Day 9**	**Day 10**
Exported Fruits (Netherlands)	26.63333[a]	18.13333[a]	13.567[a]	6.233[a]	5.4[a]
Chilled (5^0C) & ripened	20.76667[b]	16.86667[b]	11.1[ab]	8.333[a]	5.2333[a]
Unchilled (Room Temperature) & ripened	18.6[c]	15.26667[c]	8.233[b]	6.4[a]	4.1[b]

a, b and c indicate significant differences.

Oil Content of Avocado Fruits during Ripening

The oil content of avocado analysed in Netherlands was significantly low at 6.7% in 6thday but gradually increased to 9.026% on 10th day as shown in table 2. The increased oil concentration reported during this storage and ripening was related to reports found by (Polari et al., 2021), who found that increased oil content during storage is due to postharvest dehydration which increases lipid recovery thanks to partial cell wall breakdown.

There was significantly low oil content in fruit sample obtained in Netherlands compared to Kenyan samples. The low oil content was significantly contributed by poor transportation which resulted from mechanical damage. This result correlates with the result gotten by (Naim et al., 2024) who found that poor transportation and compression leads to reduction of avocados oil content. This reduction in oil content indicated a negative impact on the fruit's texture and flavour and these avocados were less creamy.

Table 2: Changes of oil content (%) of avocado fruits analysed in Netherlands (exported fruits) and in Kenya (chilled and unchilled).

Samples	Days after Ripening				
	Day 6	**Day 7**	**Day 8**	**Day 9**	**Day 10**
Exported Fruits (Netherlands)	6.73333[c]	7.86667[c]	8.7[c]	9.03333[c]	9.26667[c]
Chilled (5^0C) & ripened	8.49667[b]	9.76667[b]	10.73333[b]	11.46667[b]	11.76667[b]
Unchilled (Room Temperature) & ripened	10.02333[a]	12.33167[a]	13.50667[a]	13.76667[a]	13.97333[a]

a, b and c indicate significant differences.

Changes of Soluble Solid Concentrate of Avocado Fruit during Ripening

The brix level of avocados in Netherlands were significantly lower with initial brix index of 7.3°Bx but slightly increased to 8.67°Bx by 8th day but declined to 7.67°Bx by 10th day, suggesting a possible sugar breakdown or different ripening behaviour.

Table 3: Changes of soluble solid concentrate(°Bx) of avocado fruits analysed in Netherlands (exported fruits) and in Kenya (chilled and unchilled).

Samples	Days after Ripening				
	Day6	**Day7**	**Day8**	**Day9**	**Day10**
Exported Fruits (Netherlands)	7.3333[a]	8.3333[a]	8.6667[a]	8.6667[b]	7.6667[b]
Chilled (5^0C) & ripened	6.6333[a]	8.3333[a]	8.7667[a]	9.4667[a]	10.0333[a]
Unchilled (Room Temperature) & ripened	7.3333[a]	8.3333[a]	8.3333[a]	10.2[a]	10.3333[a]

a, b and c *indicate significant differences.*

Changes in Colour Index (Chroma) of Fruits during Ripening

The avocados analysed in Netherlands showed colour change at 4.63 on 6th day but increased rapidly to 16.43 by 10th day. Fastest colour change, suggested accelerated ripening, due to higher susceptibility to stress. The unchilled avocados started at 2.69 on 6th day and increased to 9.58 by 10th day. This showed moderate colour change, suggesting natural ripening under ambient conditions. Chilled avocados started at2.49 on 6th day and increased to 9.66 by 10th day. There was slowest colour change initially (6th –8th day), but by 10th day, it reached the same level as unchilled avocados**.** Chilling delayed early ripening but had little effect by 10th day. These results agree with the behaviour of colour change in avocado 'Hass' variety reported by Xavier et al., 2024who observed that Hass varieties characteristically change colour from green to purple and eventually black. However, the ripening process was slower in Hass avocados in Netherlands, and the colour changes took longer to become apparent. External colour transitioned from dark green to yellowish-green as ripening progressed. The increasing values showed that the Hass avocados underwent a colour change from green to black as they ripen and by 9thday and 10th day the pulp were completely darkened, indicating signs of compression during handling and transportation.

Table 4: Changes of colour index (chroma) of avocado fruits analysed in Netherlands (exported fruits) and in Kenya (chilled and unchilled).

Samples	Days after Ripening				
	Day 6	**Day 7**	**Day 8**	**Day 9**	**Day 10**
Exported Fruits (Netherlands)	4.63333[a]	7.13333[a]	11.43333[a]	16.13333[a]	16.43333[a]
Chilled (5^0C) & ripened	2.49123[c]	2.63133[c]	4.65893[c]	7.58433[b]	9.6641[b]
Unchilled (Room Temperature) & ripened	2.69373[b]	3.0083[b]	5.49867[b]	7.59533[b]	9.5762[b]

a, b and c indicate significant differences.

Changes in Peroxide Value of Avocado Fruits during Ripening

Avocados analysed in Netherlands started oxidation at 2.57on 6th day and increased to 6.90 on 10th day. Highest overall peroxide values indicate faster lipid oxidation, due to handling and chilling conditions before ripening**.** This rise suggested that, while the fruits were ripening, oxidative changes occurred in the oils, which impacted the fruits' shelf life and flavour stability. This increase in oxidation does not agree with the research done by Shendi et al. (2018), who reported that peroxide value, decreases during storage because lower storage temperatures generally improve oxidative stability (Diez-Betriu et al., 2022). The avocados analysed in Netherlands might have had higher oxygen

exposure due to poor transportation and handling methods. The peroxide values of chilled avocados were significantly higher from the start (2.41meq/kg) and rose to 6.2meq/kg on 10th day indicating increased lipid oxidation as a result of chilling. The peroxide values of unchilled Avocados **s**tarted lower (1.9meq/kg) on 6th day but increased to 6.1meq/kg on 10th day, showing a steady but moderate increase in lipid oxidation. These results concur with the report given by Sarungallo et al. (2018), who found that fruits stored at higher temperatures showed faster oxidation with peroxide value increasing more rapidly.

Table 5: Changes in peroxide value (meq/kg) *of avocado fruits analysed in Netherlands (exported fruits) and in Kenya (chilled and unchilled).*

Samples	**Days after Ripening**				
	Day6	**Day7**	**Day8**	**Day9**	**Day10**
Exported Fruits (Netherlands)	2.56667[a]	3.66667[a]	5.76667[a]	6.2667[a]	6.9[a]
Unchilled (Room Temperature) & ripened	1.9678[c]	3.33333[b]	4.79997[c]	6.3333[a]	6.13333[c]
Chilled (5^0C) & ripened	2.41005[b]	3.43333[b]	5.60013[b]	5.7667[a]	6.28933[b]

a, b and c indicate significant differences.

Conclusions and recommendations

Based on the results of firmness, oil content, soluble solid concentrate, colour, peroxide value content, the mode of transportation, the handling containers and the storage temperatures significantly affect the quality of avocados fruits exported to The Netherlands. Firmness levels of avocado fruits exported to The Netherlands showed significant rapid loss of firmness over time. The oil contents of avocado fruits analysed in Netherlands were significantly lower compared to the other groups. This clearly shows that the avocados were of variant maturity conditions and also exposed to different handling conditions. Fruits exported to the Netherlands showed highest colour index shift from light green to dark and highest peroxide value, suggesting that these fruits were more susceptible to stress and prone to rapid membrane oxidation and disruption. All together, these results suggest that fruit maturity factors and postharvest management practices contributes to final fruit quality at the consumption level.

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