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

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

Advisory report




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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 publication the avocado advisory report which is based on popular papers (practice briefs) 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 23 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; they designed the website 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), Robert Baars (prof. Climate Smart Dairy Value Chains), Peter Bouma (researcher avocado value chain) & Woody Mayers (prof. Integrated Food and Production Chains)

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Management summary

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.

Twenty-two 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.

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1. Introduction of food waste in the avocado chain

1.1. Food waste and post-harvest losses in Kenya

Agriculture is one of the most important components of economic development in Kenya and an important source of food security: 80% of the population is directly dependent on agriculture as source of food and income. In addition, the agricultural sector is responsible for 65% of export earnings (FAO, 2021a). However, losses of perishable and nutrient-rich agricultural products such as milk, fruit and vegetables are extremely high (over 50% for export). Although numerous efforts have been made to address food losses in Kenya, it is now well established that innovating to reduce food losses is not a linear process that can be led by a technology push or market pull only. There are many factors that contribute to scaling up and anchoring of proven quality assurance and food loss reduction practices among small scale farmers and other chain actors. Beyond action research that tackles knowledge gaps to solve commonly encountered constraints across the different value chains, in-depth insights are needed on cross-cutting issues affecting sector performance. All these insights are needed for the leadership in cooperatives to take the right actions.

Large quantities of the agricultural harvest are lost before they reach the market or the consumer. This has a negative impact on the environment, economy and food security. The losses affect all value chain players, such as producers, suppliers, distributors, exporters, market traders, intermediaries and wholesalers (Figure 1). However, small to medium-scale farmers experience the largest relative volume of losses (FAO, 2019).

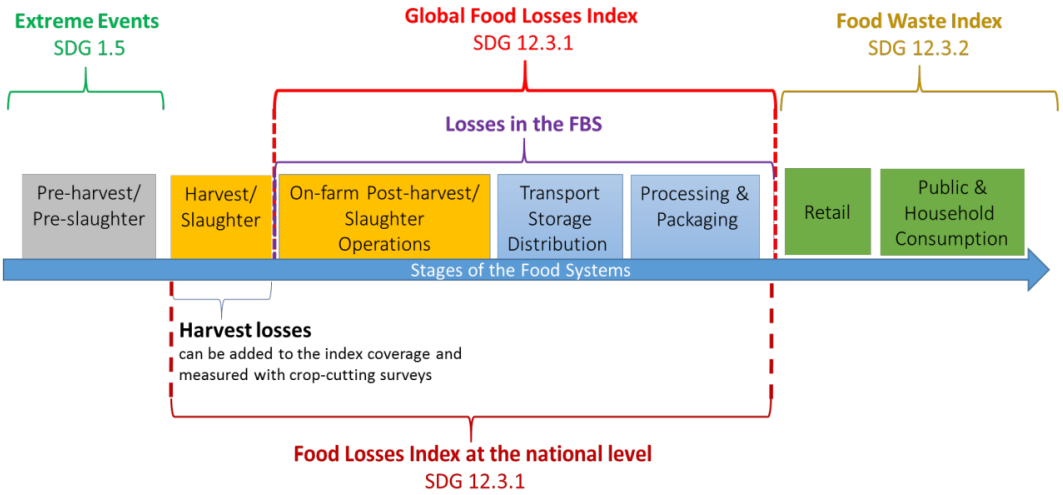

Figure 1: Food loss and food waste indexes explained towards SDG targets (FAO, 2018).

These losses have a great impact on both local and national food security status, as well as the loss of income and earnings from foreign currencies. This is not only because farmers miss out on potential income and do not recoup investments made, but also because the losses affect the local availability and affordability of food products. The food waste reduction has a direct relation with the reduction of the environmental footprint and promoting sustainability. Kenya loses almost half of its farm produce to poor infrastructure, production surplus, and policies that fail to promote local agro-processing, all of which have the potential to be game changing. It is a sustainable opportunity in which investors can work with farmers to reduce food waste and boost food security (Njagi, 2021).

Local food systems can learn from export-oriented systems. Nevertheless, this needs to be done with care. Kenya's horticultural export supply chain has revealed systemic issues relating to imbalances of power and unfair trading practices that have a significant impact on food waste levels, as well as farmer livelihoods. For example, last minute cancelations, unnecessarily strict cosmetic specifications and unpredictable fluctuations in demand and price. Financial risk is transferred down the supply chain to the weakest actors reducing living standards and forcing many into debt cycles. 'Post-harvest' losses (PHL), focus on infrastructural issues, poor harvesting methods and inadequate storage of crops. There is a need to better understand food losses in developing countries, as opposed to food waste that can be reduced independently from improvements in PHL reduction. Food waste reduction can be achieved with limited public investment, compared to PHL reduction, where the latter requires innovations in business practices to avoid unfair trading practices that force farmers to waste their produce (Colbert, 2015). In the inception phase of this SIA project, the use of the concepts of food waste and food loss were discussed (Verschuur et al., 2022).

1.2 Food waste and post-harvest losses in avocado

Kenya is the world's third largest producer of avocados. Approximately 26,000 ha of land are under avocado cultivation, leading to 420,000 tons of avocado production in 2021 (Fig. 2; FAOSTAT, 2024). Mainly three avocado varieties are produced for commercial purposes namely, Fuerte, Hass and Jumbo. Out of the total production, approximately 80,000 tons go to the export market and the rest is consumed locally or used for processing. It is Kenya's leading export fruit export, accounting for nearly one-fifth of its total horticultural exports. The avocado value chain in Kenya is relatively young. Kenya only exports a small share (14%) of its total production, but there is a potential for growth. The Kenyan avocado sector faces several challenges in increasing its export share including poor quality and regulatory standards, weak institutional capacity of small-scale producers, and inadequate capacity and coordination of fruit export (Dengerink and van Rijn, 2018). Contract farming has been proposed as the best option for Kenyan smallholder avocado farmers to transform its avocado sector with exporters. But widespread side-selling and lack of loyalty and trust threatens contract sustainability (PRESM, 2018).

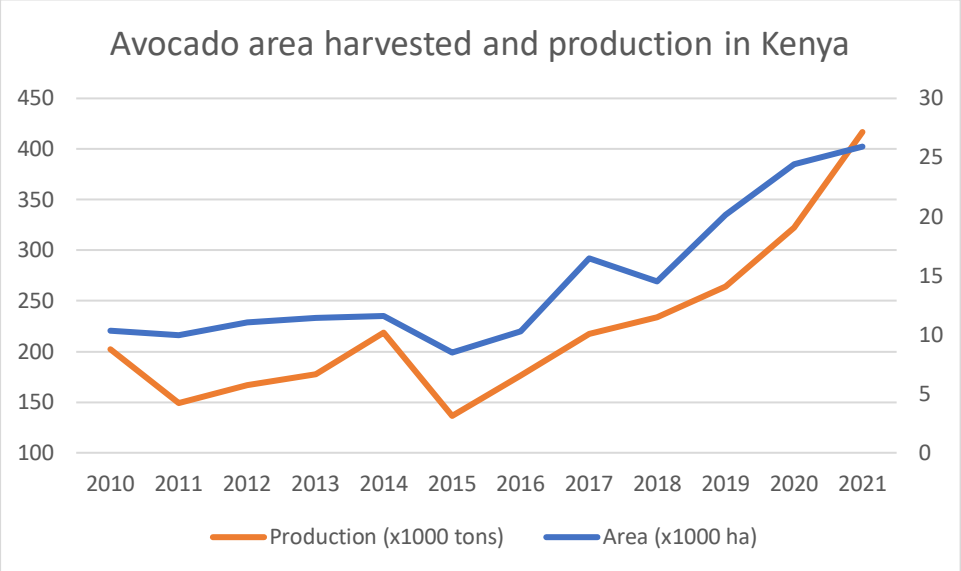

Fig. 2. Avocado area harvested and production in Kenya (FAOSTAT, 2024)

It is estimated that close to 60% of the total avocado production is lost mainly due to early harvesting of immature fruits and poor postharvest handling and management (AFA-HCD, 2018).

Improved farmer knowledge and practices has been shown as a key step in the pathway to increase income from avocado production(Dengerink and van Rijn, 2018).

Avocado harvesting, bulking and transportation from small and medium scale farmers is done and managed by middlemen of which the majority has very little knowledge on production and handling. Several sector reports have linked significant post-harvest losses to poor handing and management of fruit during transportation, sorting and grading. From the farm to several packhouses, avocado fruits are often transported in bulk in pickup and lorry trucks without being placed in crates. This leads to significant physical damage such as bruising and internal mechanical cracks due to the compression.

Additionally, avocado is produced in several agro-ecological zones and fruit maturity is known to occur at different times of the season. For instance, in lower altitude agro-ecological zones the fruit mature early in March while at the high altitude agro-ecological zones fruits achieves full maturity in June, with the midseason harvesting starting and ending in November. In Kenya there are suitable agro-ecological zones for the cultivation of avocados, organic production is also possible in these zones. The production of organic avocados is also possible. Correspondingly cooperatives have developed in the last 10 years to overtake the position of the middlemen. These cooperatives are at different stages of development and professionalism.

The organization of the chain in terms of capacity building, ICT service, (cooling) logistics, quality control and payment structure need improvements to be able to export high quality avocados and reduce the waste level (Dengerink and van Rijn, 2018; Bustos & Moors, 2018; Bustos, 2016). Furthermore, the importers have an important role and responsibility. Among others, Dutch importers (contacts of Dutch Fresh Port) are important partners for Kenya to enter the EU market. The European market (consumers, retailers, food service) are pushing the importers to take more responsibility and invest in improvements in the value chain (Van Vliet, 2021).

1.3. Research objective and research question

Objective

The objective of the SIA project was to develop new knowledge and action perspectives for local small holder farmers and cooperatives and therefore contribute to food safety in Kenya. This was achieved by doing practice-oriented research in structural reduction of food waste and food losses for the export chain through efficient business to business partnerships.
Note: the project is based on a call from SIA-LNV jointly formulated by the Netherlands embassy in Kenia and the ministry of agriculture (LNV).

Research questions formulated during the project

A. What is the governance of the avocado value chain?
   a. What is the organisation of the avocado value chain (logistics, buying, marketing)?
   b. What kind of chain (business to business) relationships (contracts, information sharing, financial) are present?
   c. What are the actual avocado losses at production, processing and distribution levels?

B. What technical interventions are required to encourage safe products and reduced food losses of avocado in both local and export-oriented food systems?
   a. What sustainable technical innovations can be implemented to reduce losses?
   b. What are the trade-offs of proposed technical interventions?
   c. What is the feasibility of ICT applications in providing transparency, traceability, increased food safety and linkages to markets?

C. What governance interventions are required to encourage safe products and reduced food losses of avocado in both local and export-oriented food systems?
   a. What is the effect of good practices on business models of entrepreneurs?
   b. What are successful scaling mechanisms for proven quality assurance and food loss reduction practices?
   c. What are effective ways to improve organizational linkages considering capacities of different private and public stakeholders?
   d. What policies impact on performance of food safety and rural entrepreneurship?
   e. What is the role of cooling, processing, packaging, quality control and certification on consumer confidence in export markets?

1.4. Research projects

The FORQLAB project was designed to facilitate 22 projects conducted by students from the Netherlands and in Kenya. The students were supported during the execution of the projects by university teachers and researchers. The business partners provided support, knowledges and assignments. This report is a compilation of the results from reports and insights from meetings (in Kenya, Netherlands and online).

1.4.1 Geographical area of the two cooperatives studied in the project

Two value chains were selected as case studies for avocado. Among them, one is a relatively well-developed and the other a less developed value chain. In the selected areas, cooperative societies were involved in the consortium (Table 1). The areas are shown in the map (Fig. 3).

Table 1. Proposed study areas

	Avocado
Well-developed	Meru (Central highlands)
Less developed	Nandi (West Kenya)

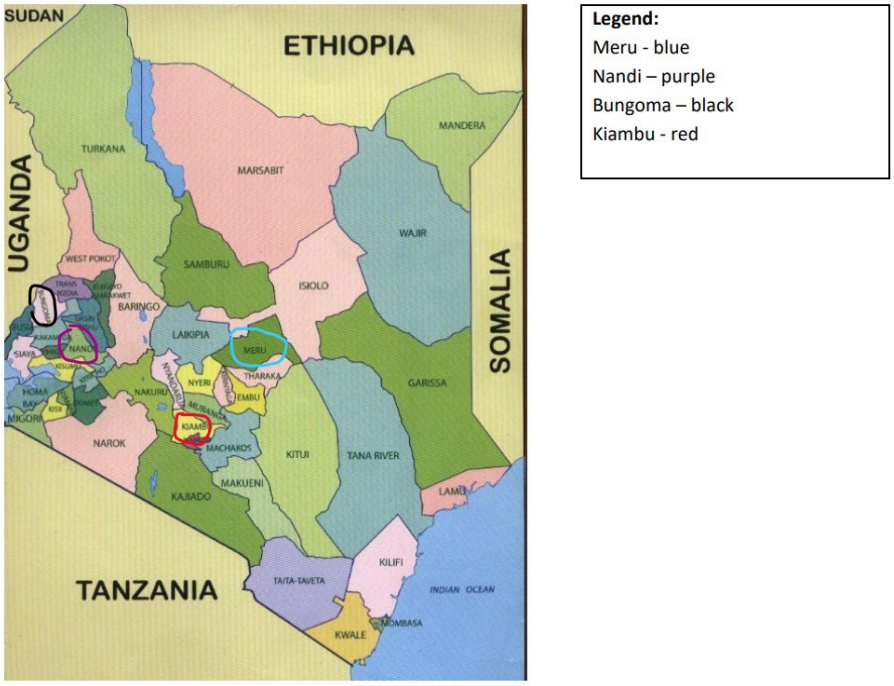

Fig. 3. Proposed study areas shown in county map of Kenya

1.4.2 Research design and approach

Different types of research were conducted in the project, depending on the required outputs/purpose of each specific research topic. This was directed by the outputs of discussion with stakeholders in the study areas and with stakeholders with in the Netherlands. All the specific research topics in the project were aligned with both Dutch and Kenyan policies, themes and strategies towards and regarding sustainability.

In total 22 specific topics/projects were deeply conducted by doing either desk or empirical research (Appendix 1). For the purposes of this report the results from the projects were organised into eight subject areas which addressed the questions listed in 1.3.

1 Avocado value Chain (AVC)
2 Understanding the rationale behind the avocado waste in the export chain (Food loss audit)
3 Product quality
4 New Products
5 Chain governance
6 ICT applications
7 New technologies
8 Export and import business cases

Most of the studies start with a comprehensive analysis of the avocado chain and the waste situation. All the reports and practice brief are available on the website of Netherlands Food Partnership: https://www.nfpconnects.com/communities/forqlab-living-lab-on-food-losses-in-kenya. All specific projects conducted within the field lab for this mission are listed in Appendix 1.

1.5 Structure of the report

After this introduction, the principal methodology is outlined in Chapter 2, focusing mainly on the approach of the "living lab" Food waste reduction and food quality living lab (FORQLAB). In Chapter 3, the results of all 22 sub project reports are combined, covering 8 aspects of the avocado export value chain and focused on the chain from) Kenya. These aspects include food loss audit, product quality, new products, avocado value chain (AVC), chain governance, ICT applications, new technologies, export and import business cases. Based on the results of the individual projects, the overall mission conclusions are presented in Chapter 5.

2. Methodology

The Food waste reduction and food quality living lab (FORQLAB) was established to structurally reduce post-harvest food losses and to improve food quality in the Kenyan dairy and avocado production chains., A consortium was established between four Dutch universities Van Hall Larenstein, HAS Green Academy, Inholland and Aeres, together with two Kenyan universities, Egerton University and Meru University. Using the Living Lab approach, private sector, government organizations, community-based organizations, and knowledge partners collaborated in applied research into the application of technical solutions as well as tools to improve coordination in these food chains.
The project consisted of four phases: 1) Inventory and inception, 2) Applied research, 3) communication of research outputs through living lab networks, 4) Translation of project output in curricula, trainings and routine business operation in the chain.

In Phase 1 needs were identified with input from cooperatives, companies, business support organizations, knowledge partners in the dairy and avocado sectors (https://www.dropbox.com/scl/fi/a4oxw58pj0tz1xtmq3h2z/FORQLAB-Inception-report_final2.pdf?rlkey=x3nw1oryalfwrpqj47f6wj6eo&dl=0). The key needs identified were :

- Strengthening and development of governance and management of cooperative.
- Data exchange and management dashboard at cooperative and chain level.
- Strengthening of the cooperation/ collaboration in the chain both vertically and horizontally.
- Development of knowledge.

Subsequently in phase 1 the following research ideas were generated within the field Lab:

a) Model for differentiation areas (high land – low land) prediction of volume and time
b) Supply chain channel decision support model based on shelf life.
c) Cheap technology to measure on farm the oil content and ripeness. Prediction model and tools for harvesting to create end-market quality.
d) Decision model for farmers (organic – traditional)
e) From the market perspective, how to combine organic and traditional to create a good balance between market and production
f) Using sensors and IT in the chain to reduce food waste. Requires a data platform structure.
g) How to improve the connection between farmers and the local chain towards the international importers.
h) What can we learn from other fresh product supply chains.
i) Communication to farmers regarding the impact (financial) of unripe and over ripe picking.
j) Development of a new transaction model in de chain (farmers receive first 50% payment after delivery to the exporter and the next 50% after acceptance in the Netherlands). How to improve the model (reduction of food waste + higher income for farmers + reduction of costs for traders /importers.

At Phase 2, twenty-two specific but diverse research topics (sub projects) were created as graduation research projects for both MSc and BSc students at the six Dutch and Kenian universities. The projects were carried out under the guidance from teachers and experts within the chain. All these sub projects were naturally commissioned through the Food Waste Reduction and Food Quality Living Lab (FORQLAB) in Kenya.

3. Results of the projects

All the project results are combined and categorized in eight topics (Appendix 1). The rationale of these topics is the practical need of the cooperatives to improve the current production and export chain.

3.1 Avocado value Chain (AVC) in Kenya

The avocado value chain in Kenya is already established but it is still developing. There are two types of chains, local and export (Fig. 4). The local chain covers around 58% of avocado production while the export chain is around 42%. There are two major types of farmers: large scale plantations and small holder farmers. This project has a focus on the small holders. Production from the local chain is sold through using informal channels. Farmers sell the avocados to middlemen or brokers in sacks. These middlemen then sell to retailers and even to consumers per piece. Due to the risks in the business, payment is in cash at farmgate where farmers receive less compared to the retailer's price. Brokers negotiate the price and link farmers to middlemen. The farmers however need to contact different brokers to achieve a good offer, otherwise brokers just dictate the price to farmers.

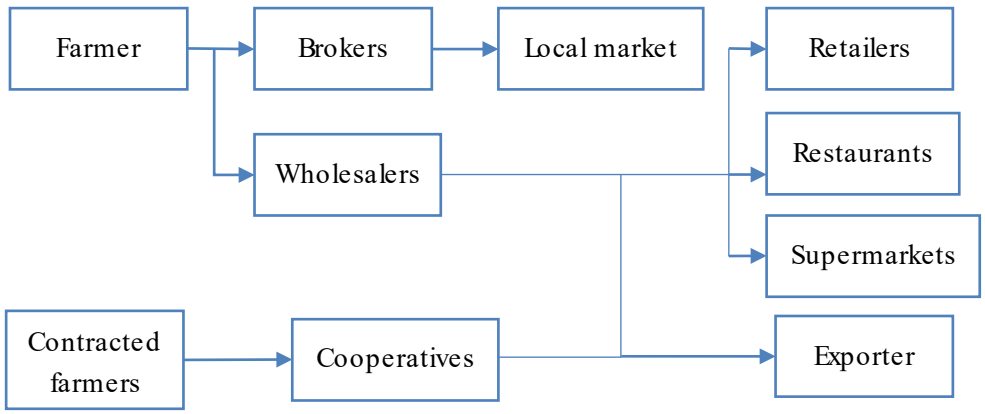

Fig 4. A simplified schematic presentation of the avocado value chain in Kenya.

Local variety value chain

Farmers in the local value chain are limited because the local variety production is sold when it is 100% mature, the product will the ripen in two days after harvest and in four days becomes spoiled due to poor transport and storage conditions. So, farmers sell to brokers or middlemen due to the time challenge. There are no formal quality standards in local chain and customers usually require high oil content avocados. This is checked by eating small part for tasting, colour inside, size and price. Fruit which is bigger usually secures the higher price. A sack of around 300 pieces is around 1000 Kenyan shillings (Ksh) at farmgate which means around 3.5 Ksh (100 Ksh = 0,70 Euro) per fruit. While the retailer price is more than 40 Ksh per fruit in the Mukutano and Mukoromune open markets in Meru town, and 75 Ksh in the NAIVAS supermarket in Nairobi. The local variety tends to produce larger fruits and commands a better price in the local market.

Export value chain

The export chain production has a formal market for farmers who are in the Abogeta cooperative and the price, quality standards and delivery conditions are described in the farming contract between cooperative and exporters. The contract is for the harvesting season, it is signed before the harvesting period and is renewed for every new cultivation season. For individual export chain farmers, the production is sold to middlemen and the linkage is done by brokers. Avocados are sold in crates. Quality standards required at farmgate are sizes between 12 and 32, green colour, and free of mechanical injuries and defects from insects and diseases.
From harvest to importer, it usually takes about 40 days (Fig. 5, Table 2). The transport to the Netherlands by boat takes anywhere from 21 to 35 days, depending on the shipping line, shipping route, and other circumstances. Now there are four companies that arrange transport by sea for reefers: Maersk, MSC, CMA, and Messina. This time-consuming process may lead to a big loss of avocado (also see the Iceberg Model in Fig. 9).

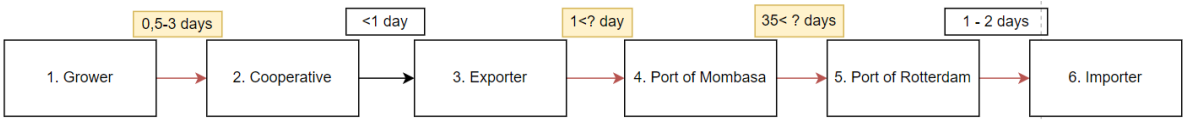

Fig. 5. Time course in the current avocado export chain

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

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

SWOT analysis of avocado value chain in Meru County
Several SWOT analyses on the AVC were conducted. As an example, the strengths, weaknesses, opportunities and threats of avocado value chain in Meru County are analysed and presented in Fig. 6. The strengths must be internally kept as they are advantages while weaknesses should be

upgraded as they are disadvantage of avocado value chain. The opportunities are factors of the external environment that avocado chain actors can seize upon to improve the chain performance and threats are factors of the external environment that may endanger competitive advantages in the chain.

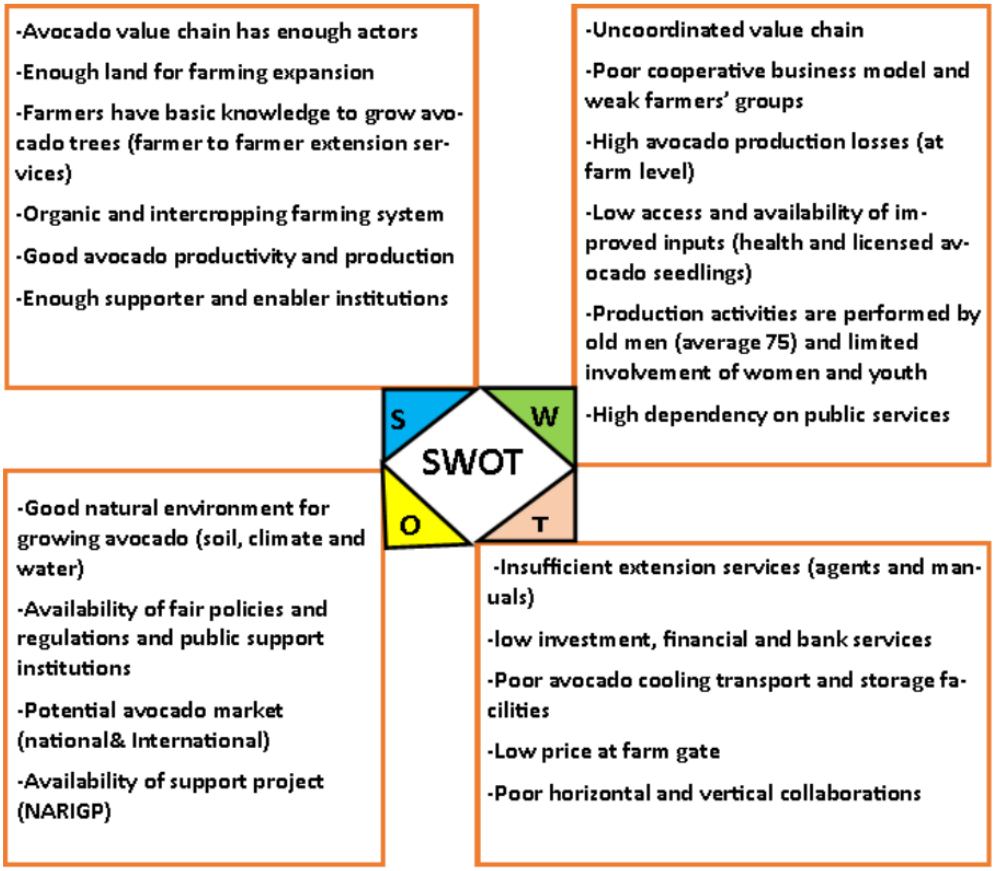

Fig. 6. SWOT analysis of avocado value chain in Meru County

To study the chain in detail, all the players are grouped as actors and supporters (e.g. Table 3 & Fig. 7). Their roles and functions in reducing avocado losses are also described in the table.

Table 3: Avocado stakeholder Matrix (of Meru County)

Actors	Current roles and functions aimed at reducing avocado losses	Categories
Input dealers	Provision of inputs such as fertilizers and pesticides to reduce pest and diseases in avocadoes. Carry out soil testing to avocado farmers to provide an accurate assessment of the soils fertility and recommend fertilizer use. Advise farmers on the safe use, handling and pre harvest interval practices of inputs, rates of pesticides and fertilizer application.	Licensed government nursery growers such as KALRO and JKUAT Unlicensed private nursery growers Licensed private Nursery growers i.e. Keitt Exporters
Producers	Adoption of traditional methods of controlling pest and disease such as wood ash, burying method, cutting down of affected trees Farmer to farmer extension services.	Based on FGD participants avocado farmers were categorized as follows with respect to number of trees: Small (1-50 trees)

		Medium (51-150 trees) Large (151 and above)
Brokers	Harvesting of required size, pedicel length and good physical appearance.	95% are men
Middlemen	Train brokers on harvesting and post- harvest handling of avocadoes	Both men and women
Exporters/ processors	Partner with Kenya Biologics, and Syngenta to educate farmers on avocado production and management Production of certified seedling Conduct field days using their own farms to train farmers.	Avocado exporters include Keitt exporters, Biofarm limited, East Africa Fresh Fruits, Key exporters and Olivado EPZ limited, Kakuzi
Manufacturers	Train farmers and middlemen on good pro- duction and management of avocadoes	Oil extractors e.g. Solfruit Kenya, Keitt Ex- porters
Wholesalers	Adoption of post-harvest handling and management practices	Local wholesalers for local varieties International wholesalers for hybrid varieties
Retailers	Adoption of post-harvest handling and management practices	95% are women Include kiosks, supermarkets, and roadside seller
Supporters		
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	
KEPHIs	Conduct inspections to ensure adherence to export quality requirements Offer phytosanitary and safety trainings and certifications	
Financial Institutions	Provision of credit facilities	
Influencers	Current roles and functions aimed at reducing avocado losses	

Ministry Agric., Livestock & Fisheries	Governs the horticultural and food subsector	Develops, coordinates and oversees implementation of all agricultural politics and activities in the entire country.
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	
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 ser- vices and internet.	
Meru University	Conduct open days for farmers where farmers are trained on good agronomic practices provision of certified avocado seedlings	
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	

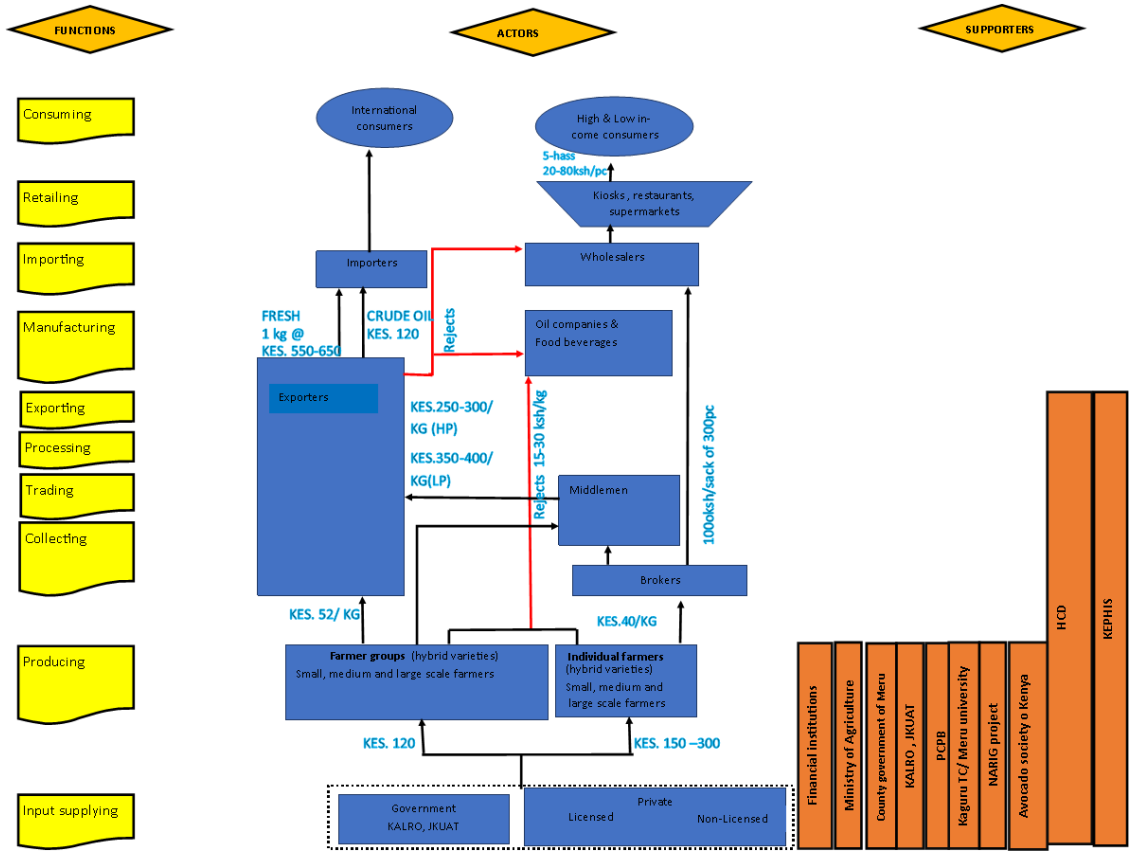

Figure 7: Avocado chain map of Meru County

Regardless the type of AVC (Local variety value chain vs Export value chain), it is constantly affected by political, economic, social, technological, environmental and cultural (PESTEC) factors either negatively or positively. Therefore, many bottlenecks are identified in the supply chain:

- There is little knowledge among growers about growing and harvesting avocados.
- The grower will harvest when prices are high, or the middlemen visits the farm regardless the ripeness.
- No cultivation records are kept.
- Growers are often not certified.
- Farmer's storage creates FLW. This is because the avocados are stored here without adding value to the avocado. In addition, the avocados are not cooled immediately after harvest this can cause the avocado to lose quality.
- Small volumes make transport expensive.
- Due to poor infrastructure in rural areas, it is difficult and costly to transport avocados. This also creates FLW (Dashboard, 2022).
- Because of the sorting process, FLW arises. Only the avocados that meet the customer requirements can be delivered. The other avocados must be sold in another market. This may be to the domestic market or the avocado oil market (Van der Hulst, Rikken & Finlayson, 2021).
- At the exporter, the avocados wait until they are loaded for transport.
- At the port of Mombasa, the container must wait before it can be loaded onto the ship.
- There is no direct connection between Mombasa and Rotterdam.
- FLW is created when avocados are sold from importer to retail. This FLW arises because of the prognosis by retail. This is because retailers always want avocados on their shelves. For this, they set a forecast. From this forecast, the quantity of avocados needed is matured. But because the forecast regularly exceeds sales, too many avocados are ripened.
- Communication between links is not sufficient.

Due to all the bottlenecks, past-harvest avocado loss and waste may occur at any time in the chain (Fig. 9a & 9b). The reasoning for the loss and waste is described in Chapter 3.2.

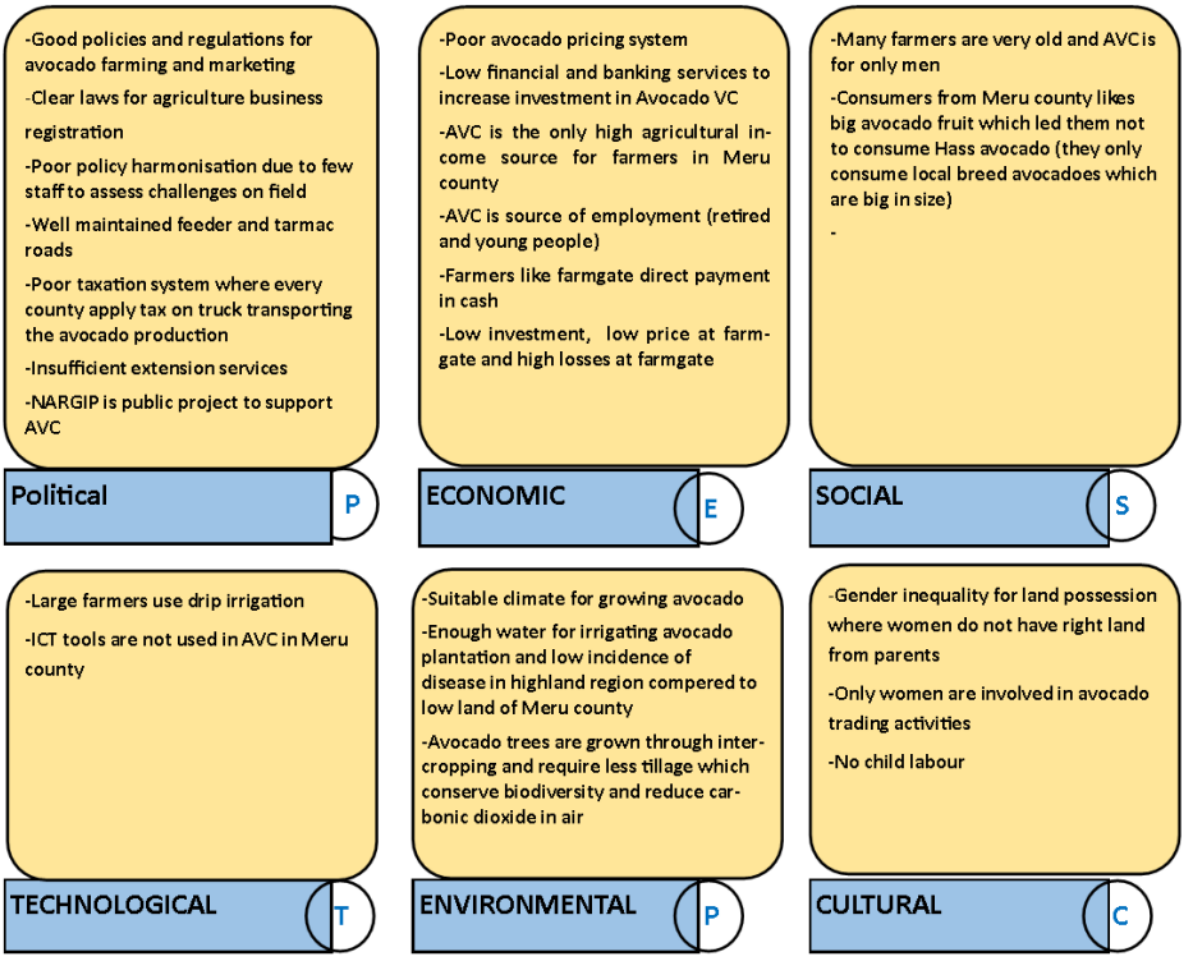

Fig. 8. PESTEC factors affecting the avocado value chain

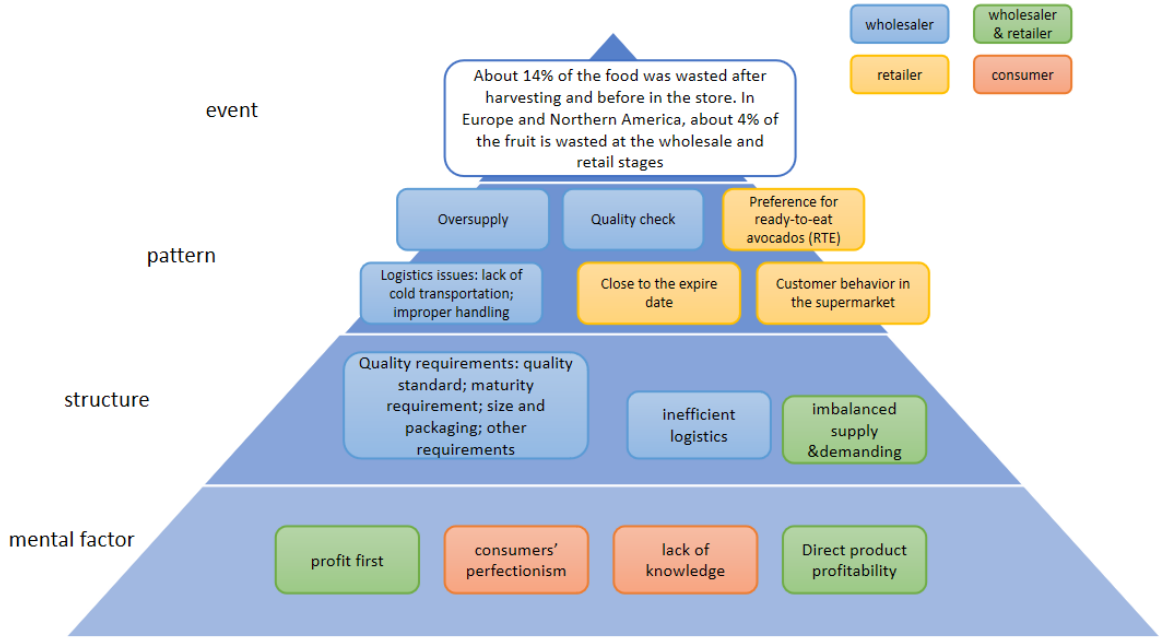

Fig. 9a. Iceberg model for avocado waste in the avocado value chain according to literature review

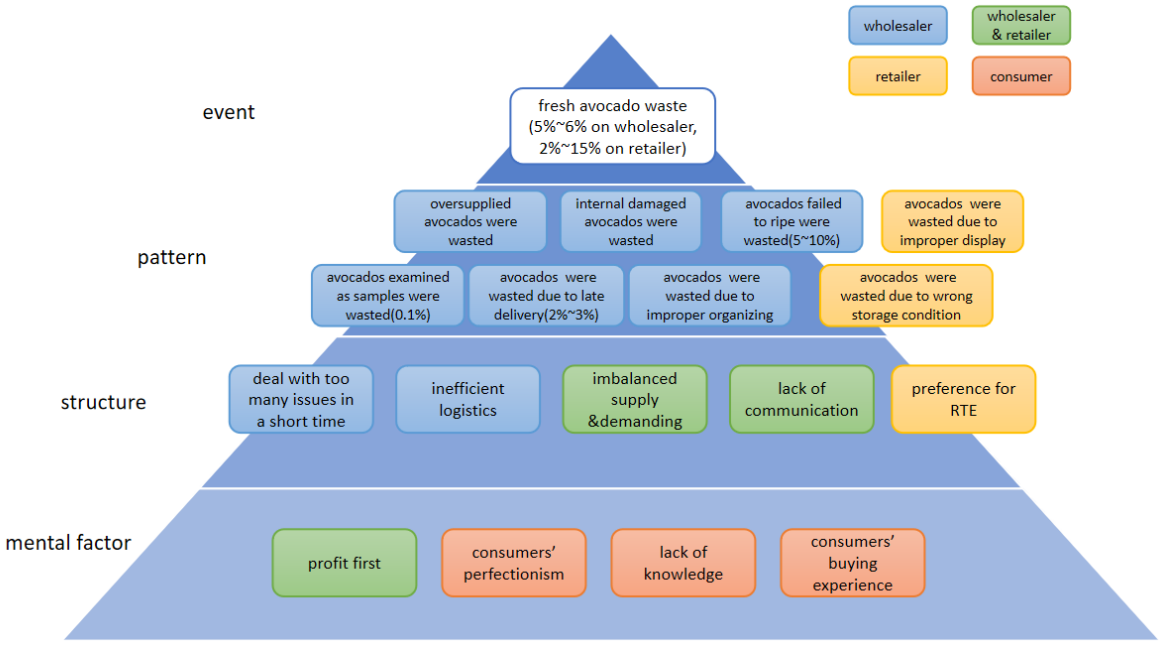

Fig. 9b. Iceberg model for avocado waste in the avocado value chain, based on current project

3.2 Understanding the rationale behind the avocado waste in the export chain

3.2.1 Avocado losses and waste in the AVC in Kenya

In the fruit and vegetable sector, wastage is, on average, around 30% across the sector, mainly taking place at the end of the supply chain. In Kenya, however, a lot of wastage already takes place at the growers because of lack of knowledge, a high proportion are smallholders and small production quantities.

Food loss and waste (FLW) consists of avoidable FLW and unavoidable FLW. Unavoidable FLW is directly linked to the supply chain, where avocados are directly lost in the chain. Avoidable FLW is not lost but used for other purposes such as feed. Avoidable FLW was assumed to occur when the cost of avoiding FLW exceeds the yields of the avocado (Luo, Lennon Olsen, & Liu, 2021). Indeed, when costs are lower, an avocado can still be processed into other products such as avocado oil.

With the aim of getting a good overview on the loss and waste of avocado in every stage of the value chain, three projects were conducted by students from both HAS and VHL (Appendix 1) to analyse food loss and waste (FLW) at the production, collection, processing, distribution, and consumption level with focus on smallholder farmers in avocado value chain in Nandi County, Kenya. The methodology used in the project included literature review, survey, interviews and observations.

It is revealed that most farmers own 10-30 trees. Around 60% of them are cooperative members. The most popular variety in mono-cropping is Hass, followed by Fuerte. A few farmers mix these two varieties.

The product flows in Nandi avocado chain to the consumers through various channels (Fig. 10). The export market is clearer where the buyers and traders such as the cooperative and export company are well connected and transparent. Brokers and traders form an informal channel where they determine prices. The chain has many loops and actors from the production to the market. The majority of the smallholder farmers (60%) are members of the cooperative which act as a market link between farmers and the exporters. Both farmers who are members (60%) and non-members (40%) sell their produce through the cooperative. However, about 36% of the smallholder farmers who are members of cooperative are unsatisfied with the cooperative. The majority of the producers use less advanced technology in production and harvesting. Transportation is done through open pickups at times on motorbikes where the avocados arranged on the first layers are exposed to direct sunlight. Transportation to the export companies is by lorries which lack cooling system. The cooperative has partnered with only two exporting companies KEITT and Sunripe exporting company. Additionally, the cooperative has also partnered with the county government which provided technical supports and help connecting the cooperative with export companies.

Farmers in Nandi sell their avocado to more than one buyer. However, most farmers sell their avocado at the cooperative only which recorded higher percentage frequency of over 48% while those selling at both the cooperative and the retailer had the least frequency of 3%. The selling channels between farmers and buyers in Nandi are shown in Fig. 6, showing the complexity of the chain and the stakeholders involved. Other project chain analyses show the same picture, the export chain is complex with many actors and stakeholders.

Similar as in Nandi, the Meru avocado value chain also consists of export and local markets (Fig. 11). The export market majorly deals with Hass and Fuerte. The chain consists of different supporters and actors with functions such as input supplying, producing, collecting/aggregating, processing, exporting, manufacturing, wholesaling, retailing and consuming. There are five major channels that avocados flow through in Meru County (Fig. 12).

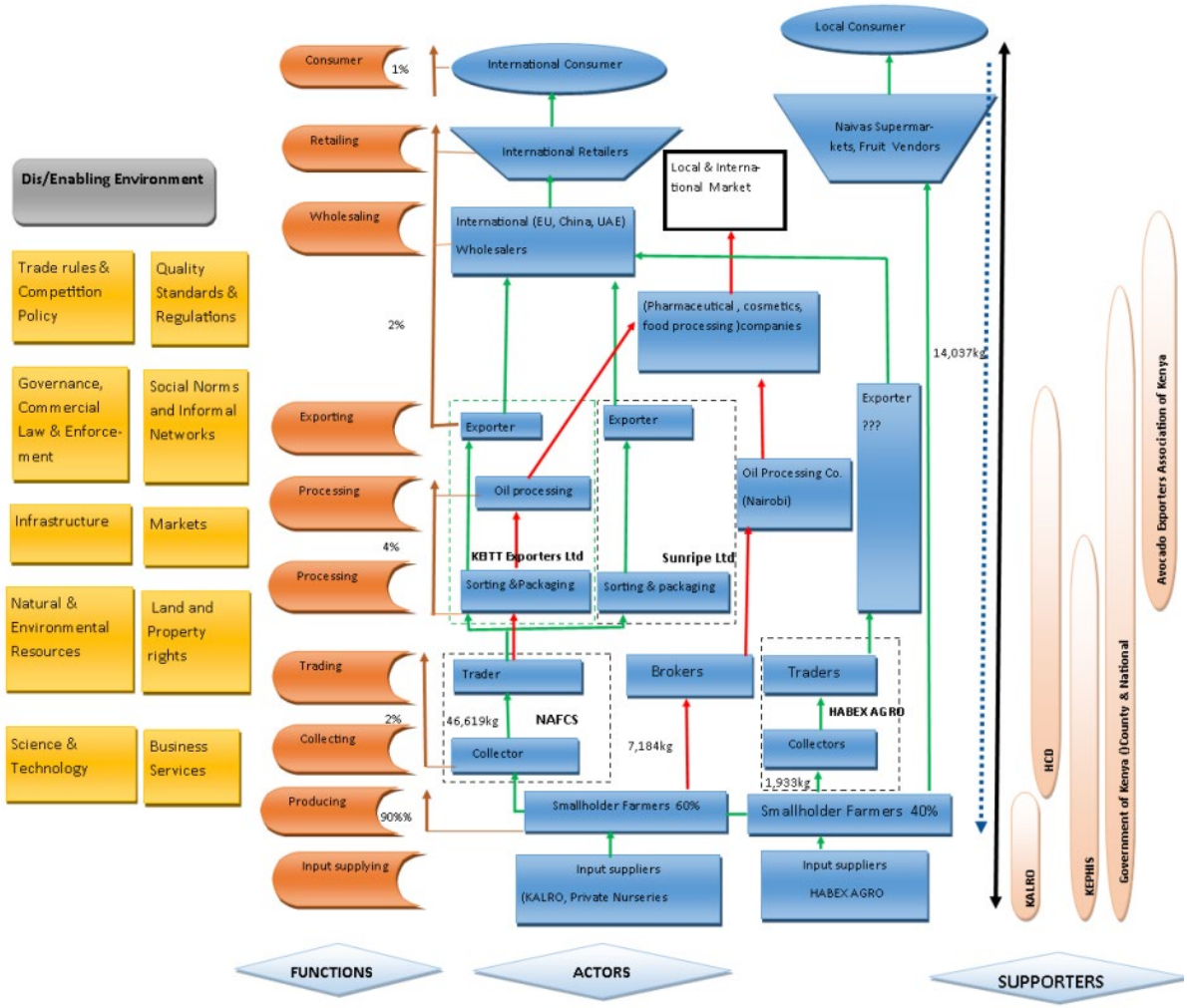

Fig. 10. Avocado Value Chain in Nandi County, Kenya (Okech et al., 2022). Solid arrowheads in green - Food flow, in brown – Residual flow, in red - out of scope flow, in black – information flow, dash arrowheads in black – Cash flow.

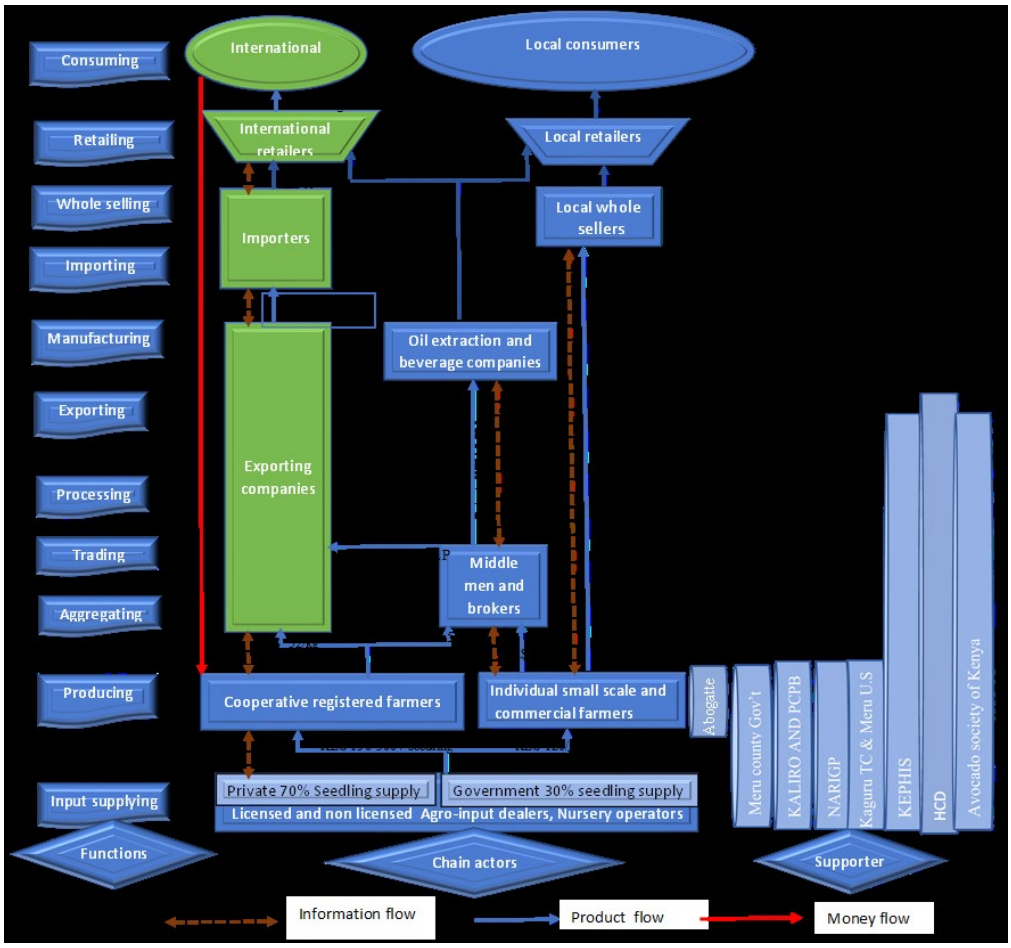

Fig. 11. Avocado value chain in Meru-county (Asekenye et al., 2022)

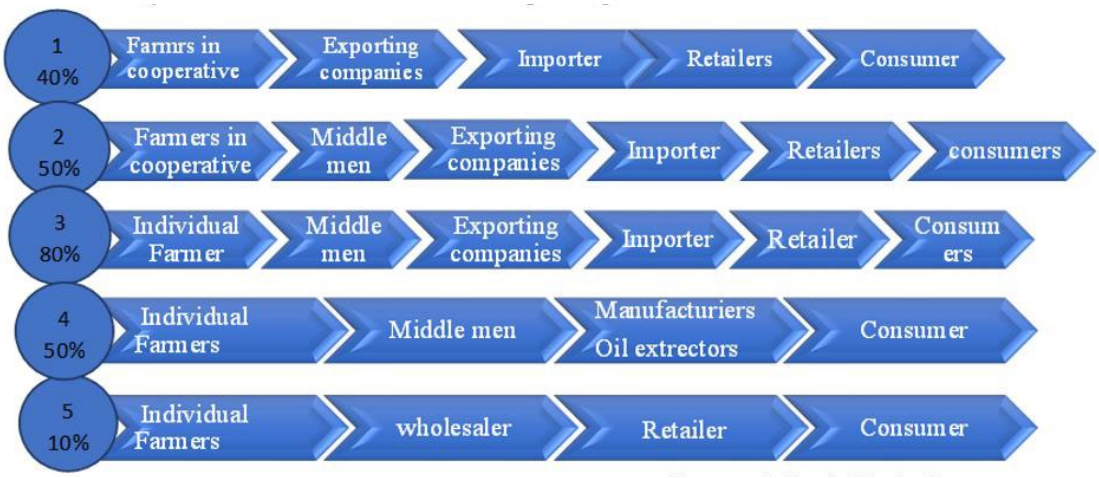

Fig. 12. Quantities and channels through which Meru avocados flow (Asekenye et al., 2022)

On average, the loss and waste of avocado in Kenya was observed in the whole value chain to around 48% of the total production. The loss & waste at production level is about 25% of the total harvest, and 23% (of the total harvest) at post-harvest level including collection and storage, processing, distribution and consumption. At the production level, the major cause was environmental factors which represent drought, hailstones, pest and diseases, and premature dropping of the fruits. Regarding the causes of loss & waste at the production (On-farm) level, eight possible reasons were pointed out by the farmers. According to the degree of importance, these were sequentially 1) Poor agricultural practices; 2) Poor Pest and disease management, 3)

Inaccessibility to market, 4) Insufficient supply of protective net, 5) Low Labour force, 6) Poor Infrastructure, 7) Lack of irrigation system and 8) Poor seedling quality.

The highest post-harvest losses (PHL) are observed during processing and packaging (49% of the total PHL), followed by collection and storage (26%) and distribution (25%). The reasons for PHL are due to 1) Lack/Insufficient storage facilities, 2) Bulk Loading, 3) Poor handling during packaging and transportation, 4) Poor avocado quality and, 5) Poor handling during offloading. It was shown in the survey that the majority of the farmers (~43%) used sacks to empty their produce after harvest for marketing while 35% used buckets, 15% placed the avocado on the ground after harvest and only 8% used crates.

At the Collection Centre over 35 smallholder farmers reported that most of their produce is rejected by the cooperative due to physical damage. None of the respondents reported issues of dry matter among the major cause of the rejection (Fig. 13).

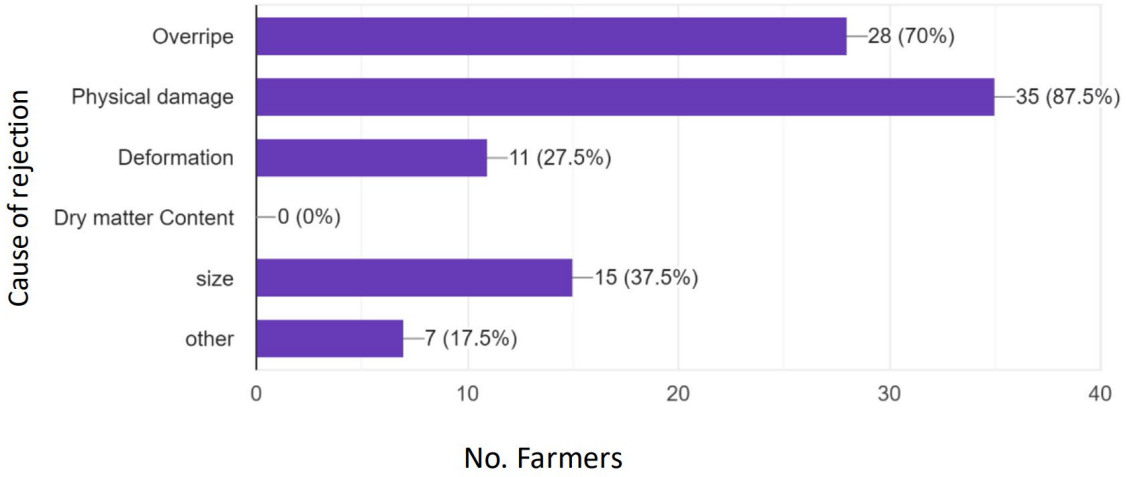

Fig. 13. Causes of loss & waste at the Collection Centre

Consequently, there was a significant effect of avocado loss & waste on the economic value within the avocado value chain in Nandi (Table 4). The total losses are presented between April and August 2022 was KES 33,131,886. Producers lost an average of 341,566kgs which is equivalent to KES 16,970,146. The cooperative presented the least economic value of KES.750,690. Similar situation is also true in Meru County.

Table 4. The effect of avocado loos & waste on the economic value within the avocado value chain in Nandi

Value chain stage	Yearly total loss (kg)	Average price (Ksh)	Economic value (Ksh)
Production	309,957	54.75	16,970,146 (52%)
Storage & collection	8,341	90	750.690 (2%)
Processing	15,365	850	13,060,260 (39%)
Distribution	7,836	300	2,350,800 (7%)
Total	341,499		33,131,886 (100%)

3.2.2. The rationale behind the avocado waste in the chain

To reduce the waste of fresh avocados from Kenya to the EU markets, the Iceberg model was used to investigate the possible reasons for the unconsumable avocados in the AVC from wholesale to retail in the Netherlands.

3.2.2.1 The patterns leading to unconsumed fresh avocados

Oversupplied avocados were wasted
During certain seasons, wholesalers imported excessive volumes that surpass their capacity to manage them promptly. Consequently, the surplus led to storage facility shortages, preventing fresh avocados from being stored at optimal low temperatures prior to ripening.
Additionally, the handling of large volumes within a short time frame increased the likelihood of human errors. With the pressure to process and distribute the avocados efficiently, mistakes in sorting, packing, or storing can occur. Such errors further contribute to the portion of avocados that remain unconsumed.

Damaged avocados were wasted
Exposure to low temperatures during transportation or nutrient deficiencies can result in darkening or greying of the avocado's internal portion. When such discoloration occurs, these avocados were deemed unsalable. The external damages like bruises were caused by a delivery issue, leading to unmarketable avocados.

Avocados that failed to ripe were wasted
Fresh avocados with a dry matter content lower than 21% were likely to fail in ripening.
Among the avocados placed in ripening facilities, approximately 5% were wasted due to variations in ripening rates, with overripe avocados rendering them unsuitable for consumption. The increasing preference of consumers for ready-to-eat avocados had resulted in a higher number of avocados being overripened. Uniformity in ripening stage will be a good solution.

Avocados examined as samples were wasted
A minimal proportion of imported avocados (less than 0.1%) are unconsumed because of rigorous quality inspections.

Avocados were wasted due to late delivery
Later delivery may be rejected by retailers, and the process of returning these rejected avocados to the warehouse could lead to avocados overripening during transport, and then unsuitable for sale. Logistics-related waste accounts for a maximum of 2% to 3% of the overall avocado wastage. While this percentage may seem relatively small in comparison to other factors contributing to waste, addressing these logistical challenges is crucial for minimizing avoidable losses and ensuring the delivery of high-quality avocados to consumers.

Avocados were wasted due to improper organizing
Improper organizing within the supply chain can lead to increased return rates and waste.
While additional requirements like possessing an organic certificate, minimizing plastic packaging, and displaying the retailer's own label were imposed, they do not directly cause improper organizing. However, improper organizing can contribute to human errors, such as incorrect labelling and packaging, which in turn can lead to higher return rates. Wholesalers could accommodate an additional 20 distinct packaging specifications demanded by various retailers. Human errors, such as incorrect labelling and packaging, also contributed to return rates. However, this issue was easily rectified, resulting in minimal waste.

Avocados were wasted due to improper display in the shopping places
If avocados are not displayed attractively or are not easily accessible to customers, they may go unnoticed or appear less appealing, resulting in slower sales and eventually unconsumable.

Avocados were wasted due to wrong storage condition
The storage condition in supermarkets could lead to waste, because 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.

3.2.2.2 The structural factors leading to unconsumed fresh avocados

Deal with too many issues at the same time
Dealing with a multitude of issues at the same time can overwhelm wholesalers and retailers, leading to problems such as quality issues, an increase in human errors and ineffective communication between wholesalers and retailers.

Inefficient logistics
Inefficient logistics practices often result in wastage, particularly when it comes to the transportation of avocados. One of the primary challenges is the delay in container deliveries. Such prolonged transportation time adversely affects the quality of the avocados, resulting in a significant decline in their overall freshness and market value.

Imbalanced supply & demanding
The global growth in avocado production had exceeded the growth in demand. In recent years, avocado production had increased by 15% to 20%, while the demand in Europe had only risen by 5% to 8%. Due to the contractual relations, wholesalers often accept more supply than the actual market demands.

Lack of communication
The primary challenge lay in establishing effective communication across different segments of the supply chain, including avocado growers, wholesalers, and retailers. The conflict between growers and wholesalers arose from growers' desire to maximize profit. These challenges resulted in inaccurate inventory forecasts, but the mistakes could still be mitigated.
Retailers were vital to the control of supply and demand. Wholesalers could address issues with excess stock by postponing orders while they look for alternative customers. Better coordination of ripening processes was made possible by improved communication between retailers and wholesalers. Delivering avocados at the right level of ripeness, extending the shelf life, and lowering the risk of spoilage were all benefits of adjusting the ripening process based on consumer demand.

Preference for “Ready-To-Eat (RTE)”
Retailers had diverse criteria for fresh avocados concerning their size and firmness.
Approximately 40% of all avocados were categorized as ready-to-eat. RTE avocados have a shorter shelf life compared to unripe avocados. If not properly managed and consumed within the required timeframe, they can spoil quickly, leading to higher levels of waste at both retail and consumer levels. In addition, if demand for RTE avocados fluctuates or the supply chain is disrupted, there is the potential for oversupply and subsequent waste if avocados are not sold or consumed in a timely manner. 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.

3.2.2.3 The mental factor leading to unconsumed fresh avocados
Mental factors refer to the conscious or subconscious assumptions, beliefs, and values that individuals hold about a system (Maani & Cavana, 2007). These mental factors can greatly impact

how individuals interpret and respond to external stimuli and situations, ultimately influencing their actions and behaviours.

Profit first
Both wholesalers and retailers frequently normally 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 was a common name for this emphasis on short-term financial gains. The emphasis on immediate sales goals and maintaining high on-shelf availability that resulted from the profit-first mentality sometimes came at the expense of taking waste reduction strategies into account or adopting sustainable practices. To ensure availability, wholesalers and retailers prioritized stocking larger quantities of products, even if doing so increased the likelihood of waste due to expiration or a lack of demand.

Consumers' perfectionism
There is a significant association between the importance of avocado appearance and the likelihood of purchasing sub-optimal avocados with a guarantee. The results suggest that individuals who place higher importance on avocado appearance are less likely to purchase sub-optimal avocados, even with a guarantee of edibility and taste.

Lack of knowledge
There is strong evidence of a significant association between familiarity with the best-before date and used-by date and the likelihood of purchasing suboptimal avocados. In other words, individuals who are familiar with these dates are more likely to purchase sub-optimal avocados. Conversely, individuals lacking knowledge of these dates are less likely to make such purchases.

Consumer's buying experience
There is a significant association between the frequency of buying avocados and the occurrence of purchasing avocados that were not in the best condition. This indicates that individuals who buy avocados more frequently are more likely to have purchased avocados in sub-optimal conditions.

3.3 Product quality

For the analysis of product quality, the field lab identified the following quality parameters which can be directly linked to losses within value chain.

- Compliance with local government regulations for production for local and for export markets
- Compliance with government legislation export destinations (EU)
- Specifications of the importers
- Dry matter content
- Oil content
- Stage of ripening and ready to eat concept
- Consumer driven demands from international markets

The quality of avocado refers as to the status of avocado fruits when they are harvested and when they arrive at the importers' warehouse. Avocados of "good quality" at harvest are prerequisite to start the whole value chain. Thus, the grower is the most important link in the value chain when it comes to avocado quality. From the time of harvesting, avocados can be preserved as best as possible, but not improved. To monitor the quality, dry matter content (DMC) is the first key performance indicator (KPI). For the local market, the DMC should above 21%. For the competitive international market, the DMC is to be above 24%. However, to ensure that avocados can reach the

European market without ripening too early, the DMC should be below 30%. Other quality parameters include pest infection, compliance with minimum pesticides residue levels and minimal physical damage.

Quality standards and other international buyer requirements are checked and enforced by the Horticulture crop directorate (HCD) and Kenyan Plant Health inspection services (KEPHIS). HCD checks the maturity of avocados and registers export companies. KEPHIS makes sure that all avocados for the export chain comply with the required dry matter content, are free of disease and pest defects and have a minimum residue level (MRL) of pesticides.

For either local or international markets, (speed of) ripening is crucial at each link of the value chain. Avocados start ripening only after they are harvested. To stop this process, avocados must be cooled to 5°C as soon as possible. If this is not done quickly enough, the transit time cannot be bridged before the avocados are ripe. Therefore, avocados should be chilled within 5 hours after harvesting. Thereafter, different treatments/approaches need to be taken at different ripening stage (Fig. 14). For example, different proportion of Ready-To-Eat (RTE) avocados can be obtained in storage at 8°C and 18°C, respectively, with different shelf-life (Table 5).

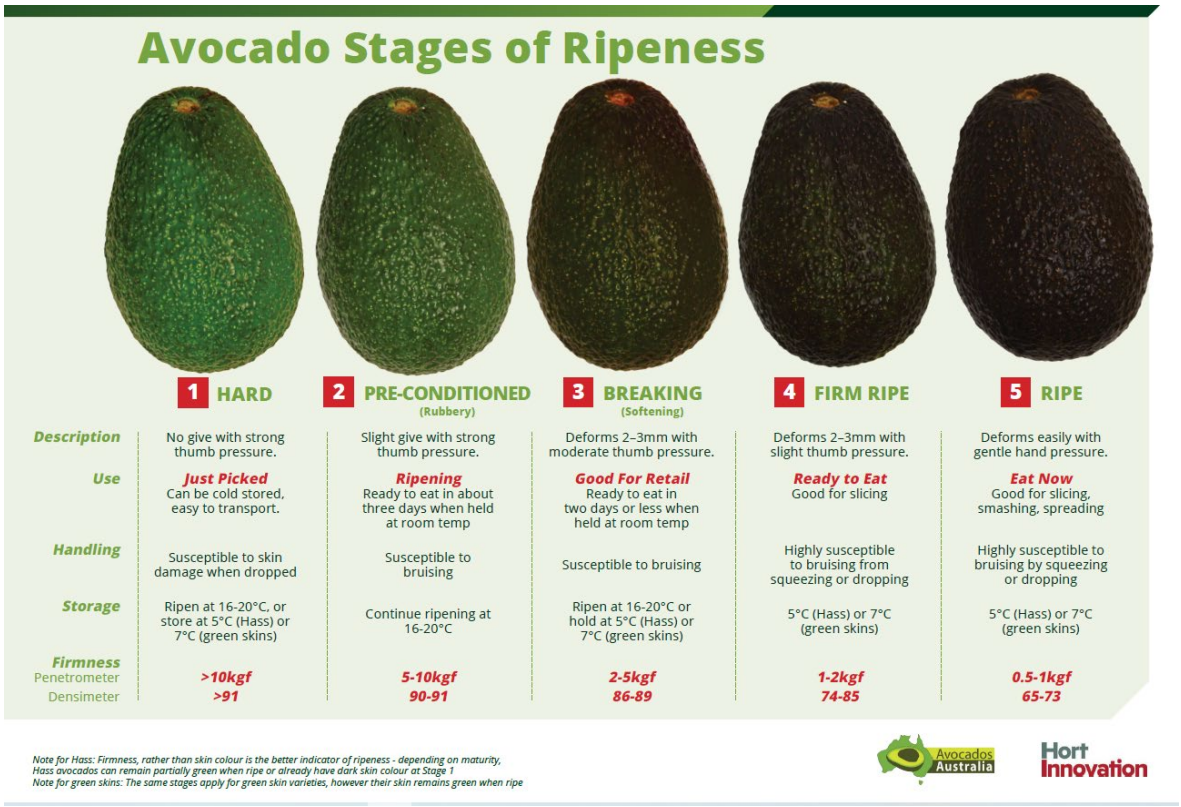

Fig. 14 Avocado ripeness (https://avocado.org.au/bpr-articles/page/8/)

Table 5: Influence of temperature on shelf life of avocados (www.eu/greenchange)

Percentage of RTE avocados in batch	Shelf life at 8 °C (days)	Shelf life at 18 °C (days)
60%	15	9
70%	10	7
80%	10	5
85%	7	3

3.3.1 Quality requirements from the EU

As the focus of this project is on the potential for the export chain to grow, specifications on the quality requirement are emphasized.

There are three classes in the avocado market in the EU, namely "Extra" class, Class 1 and Class 2. The requirements to be met for the **Extra-class** avocado are:
- The product must be intact.
- The product must be clean.
- It should be free of insects.
- It should be free of damage.
- It should be free of external moisture.
- The stalk should be no more than 10 mm.
- It must withstand transport and handling.

In addition, the difference in weight per avocados in a lot may not exceed 5%. If it exceeds 5%, the lot immediately becomes Class 1. No more than 0.5% of the lot may consist of Class 2.

The following specifications describes when an avocado may be considered under **Class 1** avocado:
- Slight defects in shape.
- Slight colour variations.
- Slight skin abnormalities.
- The stalk may be slightly damaged.

A lot of Class 1 avocados may consist of up to 10% of Class 2 avocados. But no more than 1% in the lot may consist of avocados not meeting Class 2.

The following specifications are when an avocado may be considered under **class 2**:
- The quality, shelf life and presentation should still be sufficient.
- Defects in form will be accepted.
- Defects in colour will be accepted.
- Defects on the skin should not exceed 6cm2.
- The stalk may be damaged.
- In no case should the defects affect the flesh.

Moreover, a maximum of 2% of the lot may be rotting and up to 10% of the lot may not consist of Class 1 or Class 2 avocados.

3.3.2 Specifications importer

As well as regulations of the importing and exporting country, the importer also sets requirements for the product. These requirements are checked one by one by the importer's inspectors on arrival at the importer. It is important that the inspectors do this so that the importer knows what quality products are arriving. Below are the specifications of the importer.

Overall specification
- The variety of avocado should be Hass.
- The lot should have a homogeneous green colour.
- Dry matter should be at least 22%.
- There should be a maximum of 1 week between harvesting and shipping.
- Packaging is on a pallet, avocados should be from one grower.

Class 1
- Defects should not exceed 3%.
- Multiple defects may add up to a maximum of 5%.
- The defects should not affect the flesh.
- The stem should be mould-free and attached to the fruit.
- The stem should be only 3mm.
- One size per pallet.

It is important that the avocados in a box are uniform. The avocados should all be the same size, colour and quality.

3.4 New products

The new products of avocados refer to the new forms of the fruits (organic and freezing) and specially processed products like oil.

3.4.1 New form

The organic avocados, the Individual Quick Freezing (IQF) avocados and avocado oil are considered as new product forms.

3.4.1.1 Organic avocados
The current study on the European market for fresh avocados reveals a clear 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. In the Netherlands, organic avocados can sometimes also be found (Fig. 15).

Moreover, 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 supply chains, the 'extra class' avocados are not recognized in the organic sector.

Fig 15 Organic avocado (retail Netherlands)

3.4.1.2 Individual Quick Freezing (IQF) avocados

As mentioned earlier, the lack of guarantee on quality and certificates for export due to small-scale production per farmers and seasonal production lead to 10-20% food waste of avocados. Moreover, the general production/export season for Kenya avocado is from April to September, the same as Peru, South Africa, Israel, Mexico, and Spain all with good reputation on quality, leading to a strong competition. Therefore, it is necessary to find a smart way to deal with these challenges. Among them, IQF (Individual Quick Freezing) avocado is considered as an essential way to deal with the blemish and ripeness problems.

IQF avocado is a different form of preservation to extend its shelf life and avoid the competition in peak season. This may help minimize food waste due to perishability of avocados in Kenya. Freezing product is also considered as the way to help alleviate the limitations of seasonal production by transforming excess production into a high-value and stable shelf life (long shelf life) product.

IQF avocados are traded in a similar distribution chain as other agricultural products (Fig. 16). the main frozen avocado supply countries for European market are Vietnam, Mexico, Peru and potentially Vietnam. It is shown in our market survey, only 32.5% of Dutch consumers have purchased frozen avocado, while 80% of them have bought frozen berries, and 67.5% of them have purchased frozen tropical fruits (e.g., mangoes, pineapples).

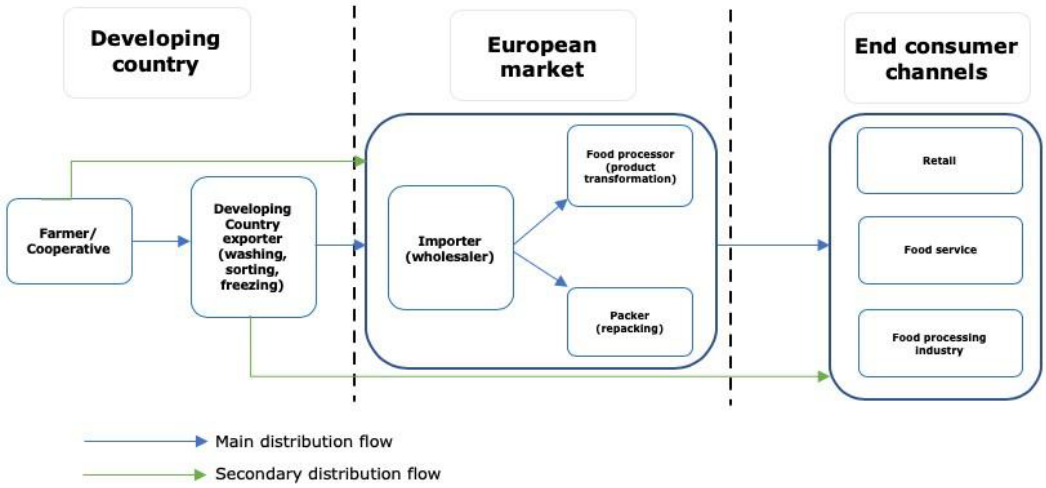

Fig. 16. The distribution chain of frozen fruits

From consumer perspective in the Netherlands about IQF avocado, 44% go for its extended shelf life and followed by its convenience/readiness, while 37% experience similar texture/taste as the fresh ones. The IQF avocados are mostly used for (making) specific foods such as smoothies. Our survey shows that price is not the only factor affecting the choice of IQF avocado, because a lower price may mean a lower quality. Instead, the presence and quantity on additives/preservatives are the major (60% of Dutch consumers) concern about the IQF avocados.

Table 6. SWOT Analysis of Kenya IQF Avocados

Strength	Weakness
1. IQF can produce almost the same texture/flavour 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. Seasonal production of fresh avocados will affect the availability of fresh avocados (raw materials of frozen avocados). 2. It's difficult to have certificates and be a part of the supply chain for small-scale farmers. 3. Due to small scale production, the traceability will be a challenge. 4. The products may be added with antioxidants to maintain the quality.
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 less care about the origin of the suppliers. 5. The awareness of the frozen avocado is limited.	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. Due to the concerning of quality, people prefer to have fresh avocado 5. B2B market prefer their suppliers are able to have traceability of their products. 6. Consumers prefer to buy sustainable products.

According to a SWOT analysis, the strength and opportunities of IQF avocados in Kenya are obvious (Table 6).

On the other hand, there are also clear challenges in Kenya regarding IQF avocado:

- Lack of international and regional standards and product specifications. This may limit the product destination due to the local food quality and safety standards, although certification can be costly. EU Regulation on Frozen Fruits include control of contaminants such as pesticide and heavy metal residuals, microbiological organisms, guarantee of temperature at -18 ℃ or lower in every step of the chain, and CSR (Corporate Sustainability Reporting Directive) reporting to keep track on sustainability in the whole chain.
- Competition with the fresh market in the industry (Fig. 17).
- Lack of cold storage facilities. This is also known for the fresh markets
- Lack of processing capacity. However, if more machines are installed, underutilization would become a new problem during low production season.

Fig. 17. Porter's 5 Forces (from the research)

3.4.2 Processed products: avocado oil

One of the processed avocado products is avocado oil which may be directly consumed or used in cosmetic industry (Fig. 18). A market survey shows a great potential for avocado oil (Fig. 17). The raw material used to produce avocado oil is mostly the avocado fruits that do not meet export requirements in the export chain, or those that cannot be sold to the local markets in the local chain (Table 7).

Figure 18: The beneficial property of avocado oil in the cosmetic products (*left*) and the degree of willingness to buy cosmetic products containing avocado oil (*right*)

Table 7. Destination of avocados that are waste/loss in its value chain

Chain player	Estimated percentage of 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

3.5 Chain governance

Chain Governance refers to the structure of links and coordination mechanisms between value chain actors. It is described in terms of 3R (Robustness of the value chain, reliability of institutional governance and resilience of innovation support system). Here, robustness refers to the efficient and trusted interactions, reducing transaction costs and the risks involved in enhancing product quality and safety and reinforcing the sustainability of value chain actors' relationship. Reliability is defined as how public-private cooperation, co-innovation and a public economic policy framework. It is all about policy and policy harmonisation. The resilience of innovation support system is knowledge exchange, mobilising resources and coordinating co-innovation networks, supporting technical and technological, or institutional capacity development.

The target area of this case study is Meru County where is an agricultural basket that provides a high volume of export horticulture and subsistence food in Kenya (Fig. 19). Most of Kenya's avocados thrive in Central and Eastern provinces which provide 70 per cent of the supply. Meru is one of the biggest producers in Kenya and the leader in the Eastern province in export tonnage. The crop grows between 1000 and 200 meters above sea level, especially Hass and Fuerte; while other varieties like Puebla do well in the ranges above 2500 meters in the county (Selinawamucii, 2022). The cooperatives are private registered of different crop producers including avocado growers, they are still young farmers' organisations. The research concentrated on avocado producers' cooperatives - The Abogeta West Avocado Growers and Abodoguci avocado growers' cooperatives in Meru County.

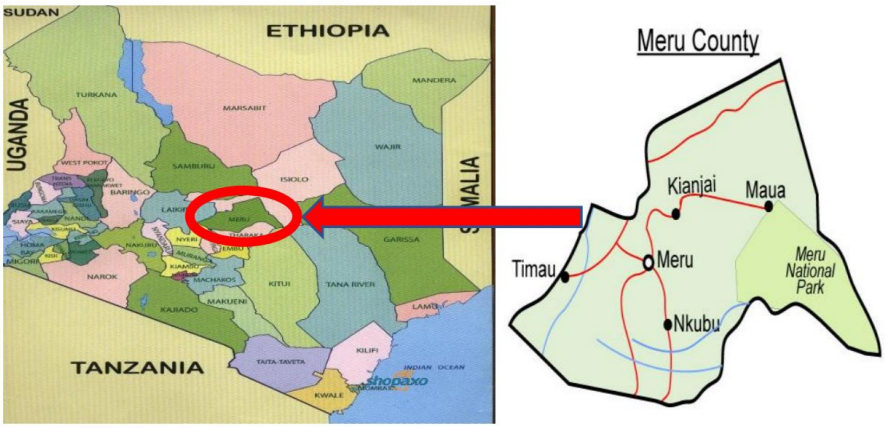

Fig. 19. The location of Meru County in Kenya

The results are based on the interview with twenty cooperative members/farmers (14 small holder, 3 medium and 3 large farmers), 1 broker, 3 middlemen, 2 retailers and 2 input suppliers. Here smallholders owned 1-50 trees, medium 51-150 trees and large >151 trees.

3.5.1 Robustness of the avocado value chain in Meru County

The robustness of the avocado value chain needs to be strengthened because gaps were identified in the chain (Fig. 20):
1) in chain actors' coordination where only 30% of avocado farmers are members of cooperatives which are also young;
2) avocado chain stakeholders do not have an active platform for empowering farmers and stimulating smooth flow of information, product flow and strong and formal relations;
3) There is no availability of adequate transport and storage facilities which can play a crucial role in the reduction of avocado production losses at the farm level.

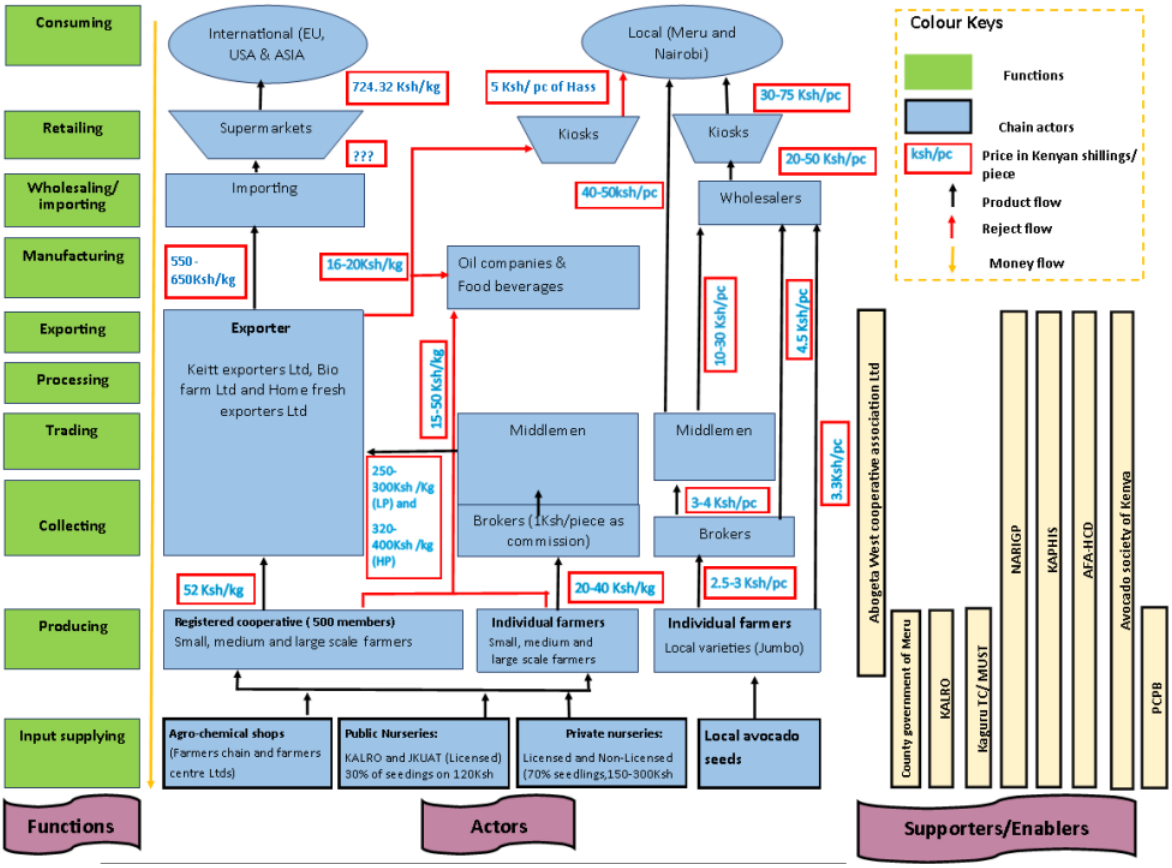

Fig. 20. Avocado value chain flow from farmer to consumer (Habineza et al., 2022)

3.5.2 Reliability of institutional governance in the avocado value chain

There are clear policy documents in the Horticultural crops directorate (HCD), Kenya plant health inspectorate services (KEPHIS) and Meru County government. For example, KEPHIS Act cap No. 54 of 2012, state corporations Act cap 324 and seed and plant varieties Act (CAP 326) laws and regarded policies and regulations have been developed for governing regulation of phytosanitary measures in production of seedlings and subsidies, quality and standards of avocados. The use of required inputs and chemicals is controlled by PCPB. The cooperative and export companies' registration and implementation plan of quality standards and requirements of international buyers, packhouse and product transport and storage requirements are checked and licensed by HCD based on the AFA Act of 2016, Crop Act (No. 16 of 2013). However, there are few awareness campaigns due to shortage of staff and funds which affect the implementation and harmonisation. The policy harmonization is stimulated by the Kenya avocado society for its members, but few farmers are members, but Abogeta cooperative is a member. Supporters and enablers wait for the farmers to apply for the services due to the shortage of field staff.

In addition to the challenges regarding policies and laws awareness, low supply of certified Hass seedlings pushes farmers to plant noncertified planting material produced locally. As a result, avocado quality and standards cannot be guaranteed at the farm level due to the chain supporters who have a shortage of staff and thus affecting the harmonisation processes. Furthermore, farmers claim to receive an insufficient and inadequate extension service and feel excluded from financial services. The chain is not inclusive because only 4% of cooperative members are women. Young people are only involved in broking and picking activities, this shows the inaccessibility of women and youth to production enterprises. In addition, the average age for men is 70 years old, thus the

sustainability in avocado value chain in danger. All identified leverage points need to be ameliorated through partnerships.

3.5.3 Resiliency of avocado value chain innovation support system

Although there are enough actors, supporters and enablers in the avocado value chain in Meru County, 84% of interviewees call for innovating the collaboration. The collaboration between the actors in terms of product flow is in place but information flow is not. Farmers and key informants interviewed said that stakeholder platforms need to be harmonised and upgraded. There are eight main supporters and enablers, and their main activities are to develop the chain, empower farmers in extension services, reduce post-harvest losses and ensure licensed availability of planting materials.

Abogeta cooperative and individual farmers have NARIGP and KALRO as supporters which can financially support the chain and healthy HASS variety seedlings consecutively. The access to financial and nursery (seedlings production) services are not enough. According to the farmers, avocado farming does not require much investment. What is required is sufficient supply of Hass seedlings from nearby licensed nursery to avoid planting unlicensed seedlings grown locally. NARIGP is helping the cooperative to build an avocado packhouse and to recruit members to contribute to the reduction of avocado losses in Meru County. The project gave sixteen million Kenyan shillings as a grant and the cooperative will borrow from a bank the remaining money to build the pack house.

Collaboration between farmers and extension services supporters is low. All respondents only meet with extension agents based on the application where they write a letter to either public or private supporters and wait to get a response. this is subject to their availability. They do not visit farms but only instruct farmers through meetings held in the centres. The available extension services provision is called the “farmer demand extension model”. Vertical Collaboration is only active during the harvesting period and there is no trust between farmers, brokers and middlemen. When they do not have any agreement with exporters producers prefer to be paid money for their production at farmgate, even although this is very little.

3.6 ICT applications in Kenian avocado value chain

ICT applications in the avocado value chain includes traceability management and communication & data management systems. The different aspects are described.

3.6.1 ICT applications for traceability management of Kenyan avocado

Food safety is increasingly becoming a big concern for consumers for fresh food in local and domestic markets. Traceability has evolved from merely guaranteeing the movement of food through the value chain, to ensuring food safety for consumers. 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 organization and other requirements. A chain-wide traceability system in the avocado value chain will allow for end-to-end transparency in the avocado value chain. 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. Thus, it is necessary 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.

It is found that value chain stakeholders played different yet integral roles in ensuring the development of an integrated ICT-enabled chain wide traceability system (Table 8). Gaps, leverage point and trade-offs in the ICT readiness of the avocado value chain in Nandi County were identified in a PESTEC analysis (Table 9). One of the big gaps was the poor understanding by famers, leading to their avocados being rejected. There were 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.

Table 8. 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 licensing of buyers
Indirect Stakeholders and business partners in the FORQLAB project	To share knowledge 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

Table 9. PESTEC Analysis of Nandi Avocado Value Chain

P	Political	• Nandi County coordinates the agriculture policy with avocado being a priority crop for diversification
E	Economic	• Funding from Nandi County Government • Partnerships with different organizations e.g. World Bank, Equity Babk and Safaricom • Rising demand for quality avocados in domestic and export markets • Opportunity to get certifications through the cooperative
S	Social	•
T	Technological	• Increasing use of MPESA for payment service • Use of smartphone 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

In Nandi County (Onyangore et al., 2022), 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. These records only identified the farmer, variety of avocado supplied and the route name. On the other hand, it is proved by ICT experts in Kenya during interviews 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 (Fig. 21).

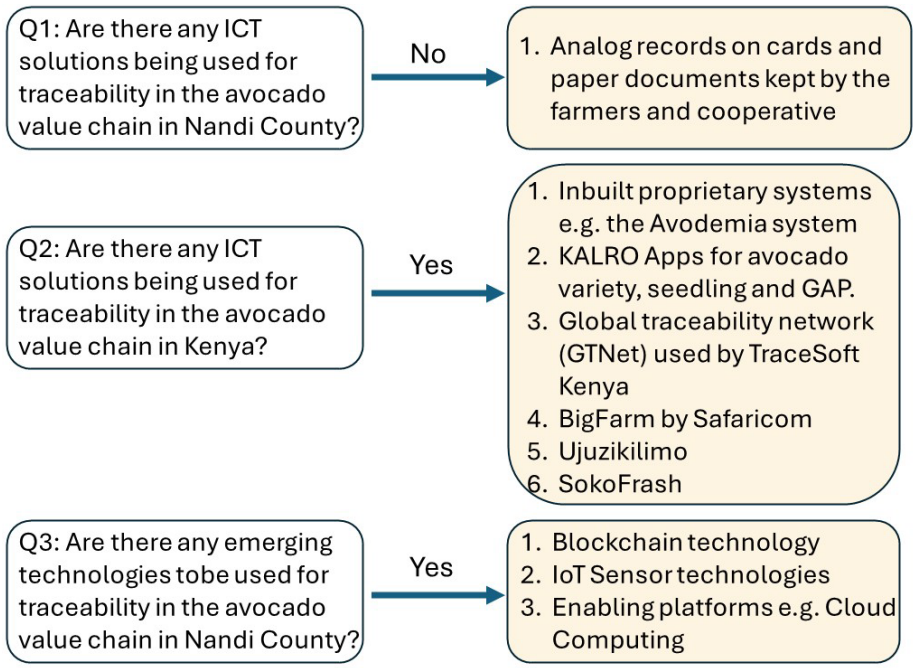

Fig. 21. ICT options in Kenya (see Fig. 22 & Fig. 23 for an impression of Blockchain technology and IoT sensor technologies)

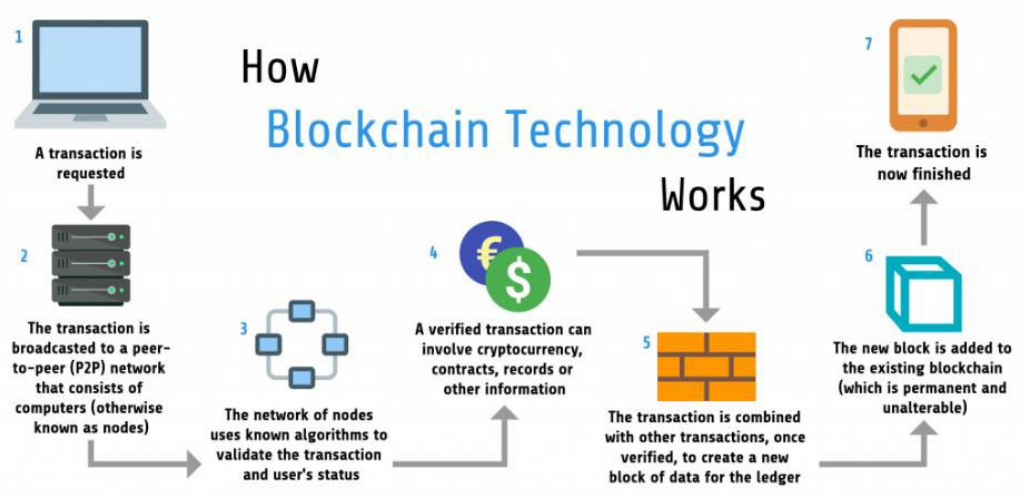

Fig. 22. Blockchain technology flow

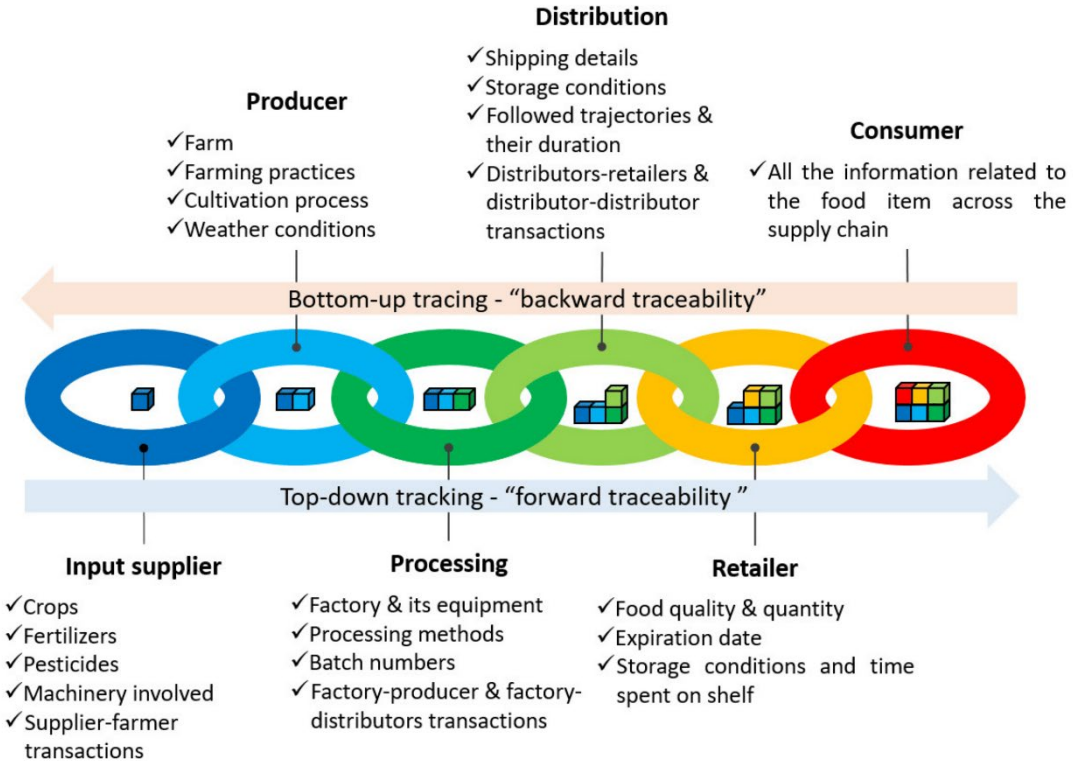

Fig. 23. IoT monitoring in the fresh produce food chain (Tagarakis et al., 2021)

Based on the current study, it may be concluded that 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 developing an integrated ICT-enabled traceability system in the Nandi avocado chain (Fig. 24).

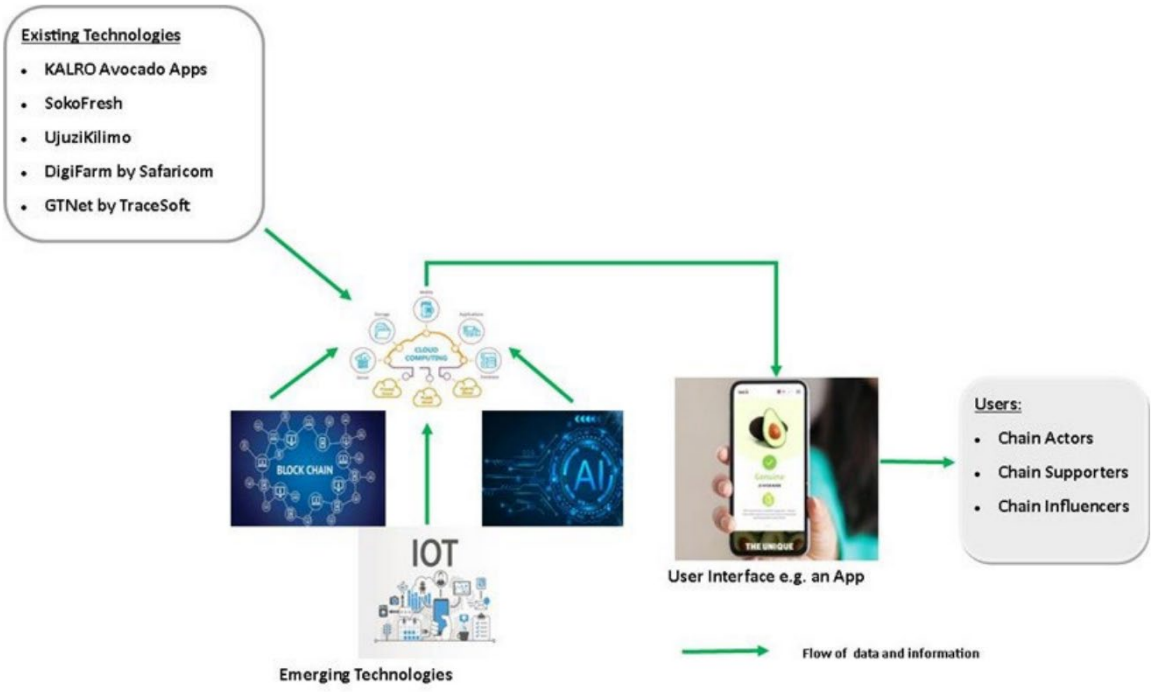

Fig. 24. Hybrid ICT-enabled Traceability System

3.6.2 ICT applications for communication & data management

So far, all activities at the farm level are manual and farmers know that ICT is for larger enterprises, the only used ICT tool is cell phones and most of the time are not smartphones. The owners of the phones use them for communicating with buyers (contracted or none contracted) when avocadoes are mature or when they are passing information between cooperative members for export chain. Digital registration of avocado products and their traceability are more used in exporters' warehouses. Exporters keep records regarding sources of avocado production (region) without knowing exactly the producers, time of unloading, the quantity of production and owners, laboratory check-up information, packing day and dry matter content.

The communication challenges of Meru County avocado farmers are outlined in Fig. 25. The challenges of the farmer cooperatives in Meru County include but limited to:

- Limited reach: Some of the farmers do not have smartphones, which limits their access to information and resources.
- Delayed Information: (Break in communication) Untimely transmission of urgent information from extension officers to cooperative executives and from the cooperatives 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.

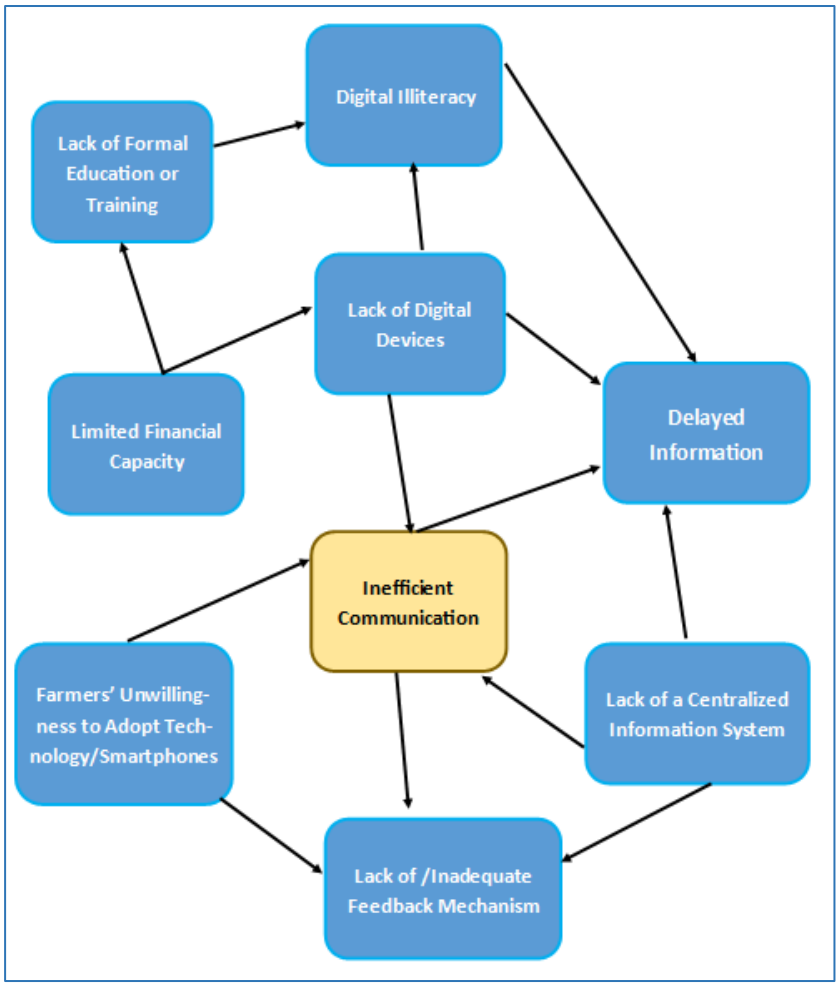

Figure 25: Causal Diagram of the Communication Challenges of Meru County Avocado Farmers

Prior to the development and implementation of desired ICT applications/platform, it is essential to have a reasonable overview on the ICT readiness. Based on an assessment, five important parameters were identified as being key to assessing ICT readiness in the avocado value chain in Nandi County (Fig. 26):

- 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

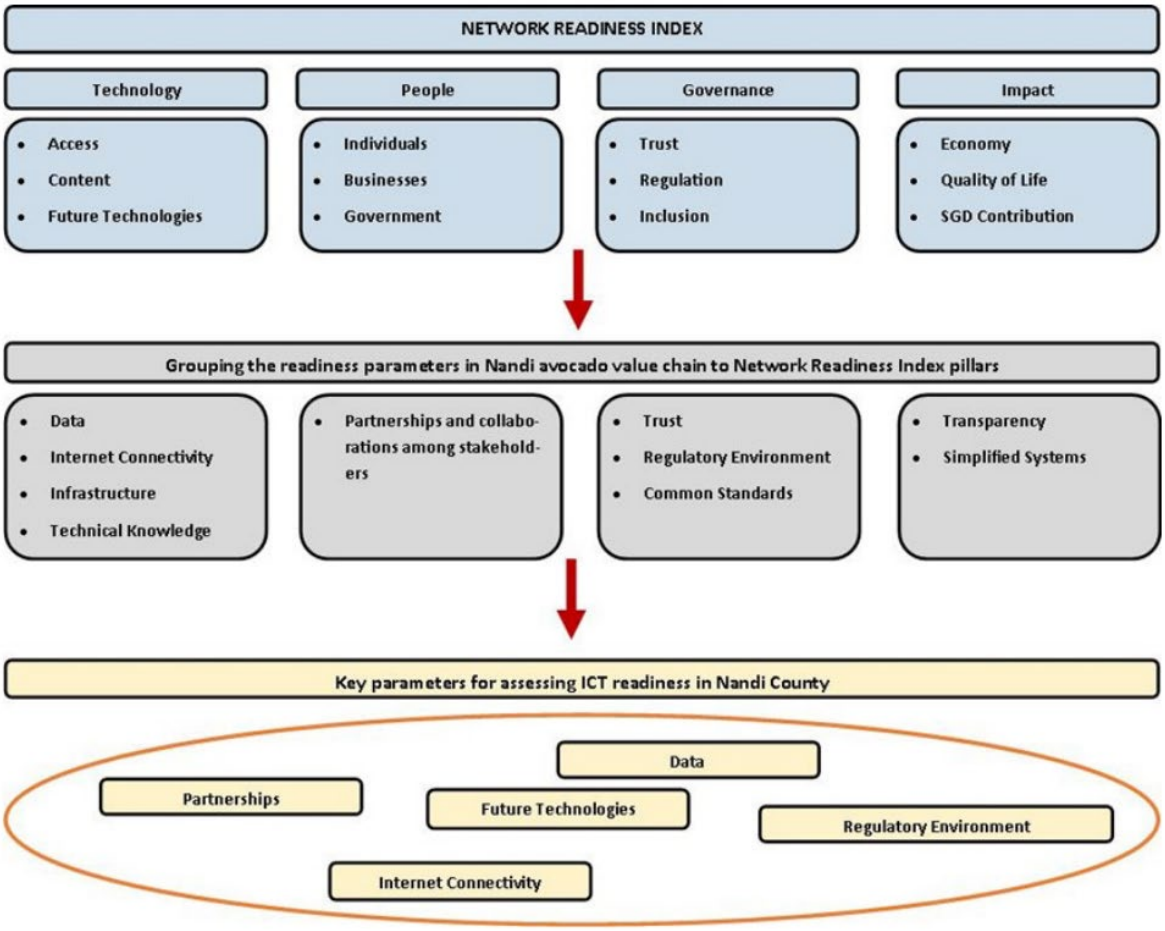

Fig. 26. ICT readiness assessment for Nandi avocado value chain

On the other hand, the needs of each actor in the chain for ICT platform were also surveyed. Here the outcomes of the survey are given:

Farmers

Farmers Needs on the ICT Application:

- Free soil testing services
- Certified seed supplier information
- Quality standards
- Information on the opening and closing of Markets
- Marketing prices with weekly updates
- buyers/clients
- Information on GAPs
- A chat platform
- Weather data
- Agricultural support (production practices, knowledge of applying chemicals to avocados)
- Hailstone insurance
- Avocado collection scheduling
- Financial statements showing the cooperative's performance
- Financial details on loan eligibility

Since 70% of cooperative farmers have access to smartphones and English is a language that is simpler to understand compared to Kiswahili and Kalenjin, they suggested that the app should be

available in English. Furthermore, awareness and training of the app is required and free access to the proposed app are all necessary.

Cooperatives

The needs on the ICT Application highlighted by the Cooperative management team in Nandi County are as follows:

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

In Meru County, the needs of the farmer cooperatives are grouped into functionalities under the following themes:

- Comprehensive member database on all members, allowing room for updates and easy report generation. Including personal data, number of trees owned, land size and location, etc.
- Production Database: Including production history with a tracking system, cumulative sales, inventory, and financial status. Record sheets that allow cumulative data on avocados harvested, quantity sold, and quantity left, etc.
- Market information: Real-time market data accessibility. Including market prices, buyer information, payment details, etc.
- Service tracking feature: Providing a concise record of agronomic services provided to farmers, including support, observations, recommendations, etc.
- Financial statement.
- Forecasting feature: Data on fruit trees and production prediction.
- Farmer feedback platform.
- E-commerce platform: Online marketplace for buying and selling avocados.
- Traceability: Ability to track avocados from our farms to the destination market, ensuring precise product origin and quality.

Transporters

During transport of avocados, a Bill of Lading should always be used. The Bill of Lading is an important document in the transport of goods. The form should contain the following information:
- Who loaded the cargo.

- Where was the cargo loaded.
- When was the cargo loaded.
- What product was loaded.
- How much product was loaded.
- Who was the carrier.
- Who was the addressee.

Labels should include the following information:
According to UNECE (Unit, 2019).
- Product
- Breed
- Origin
- Size
- Class
- Net weight
- Lot code
- Address details exporter

According to GlobalGAP (GlobalGAP, 2020)
- Packer code

According to the importer
- Address details importer

Certification
- The grower must have the GlobalGAP certificate
- A pesticide residue analysis must be present
- Packaging centres must comply with BRC (British Retail Consortium) requirements.

3.6.3 Design of the ICT Applications

Functionalities in the ICT applications for farmers:
- Chat capability feature that allows real-time communication on urgent matters and knowledge sharing.
- Financials features for savings and credit, market prices and trends.
- Data management features for gathering, analysing, recording, and storing communication data to identify trends and enhance processes.
- Support/educational features for production, weather information, and training information.
- Centralized dashboard: Provides an overview of membership profile and farm details, facilitating communication, reporting, and two-way feedback.

Correspondingly, five essential services were identified/recommended:
a) Market accessibility: Weekly updated global market prices
b) Financial accessibility: Loans, hailstone insurance, cooperative financial statements
c) Tracking and traceability: Quantity of avocado produced by the specific farm, the region of the farm, the grade of avocados, and the type of avocados
d) Information Sharing: Weather, GAPs, certified seedlings suppliers, schedule of avocado harvest collection, soil testing, and agro store information
e) Information analytics: Cooperative performance statements, the predictive quantity of harvest, predictive timing of harvest, and market prediction models (prices, demand, supply, and weather).

The key functionalities to address the needs of the farmer cooperatives are summarized here:

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

Based on the needs/wishes of all actors in the chain, all possible ICT Application features are summarized in Table 10 and Fig. 27.

Table 10. ICT Application features including its functionalities

Feature	Functionality	Destination stakeholder
Product specifications	This describes the product specifications, quality requirements and other aspects from the laws and regulations both from the EU and also from the Kenyan government. Putting these together provides a clear overview.	European retail and importer
Quality requirements	European retail adds its own quality and customer requirements in addition to specifications according to laws and regulations. The importer now has a clear overview for the final product.	European retail and importer (exporter also via importer)
Sales forecast	European retail issues forecast sales at package level to the importer who translates it into container volumes of gross product.	European retail and importer
Sales programme	The sales programme is the result of the translation at coli to container level. This forecasts, but also during the season, this information is immediately provided to the shipping company and transporters and exporters. This allows reservations to be made for the transport of containers. Also, together with the cooperative(s), the exporter can match the harvest planning accordingly.	Importer, exporter, transporter, shipping company
Transport specifications	Through the sales program, the transporter and shipping company create a transport schedule with corresponding transport specifications. These transport specifications can be used to adjust the	Cooperatives, Exporters, importers and transporters

	carriers' internal planning to that of the cooperatives, exporters and importers. Each transporter in the supply chain can thus view its share of information.	
Harvest planning	Harvest planning follows from observations made by the field supervisor. The field supervisor makes the harvest program with the cooperative based on observed quality at individual growers.	Cooperative
Cultivation registration	Cultivation records are kept by the field supervisor and follow from the work done by the grower. Pruning and fertiliser application are examples. These activities affect the quality and volume of avocados per grower and reflect a good stage of the orchard. In addition, this is the basis for certification such as GlobalGAP.	Cooperative
Quality forecast	The quality forecast follows from the cultivation supervisor's observations at the grower's premises. Through the quality forecast, estimates can emerge with the quantity of harvested avocados of suitable quality for export. This can also show the degree of "Maturity or Maturity" of the fruit.	Cooperative
Harvest programme	From the harvesting programme, it will see which grower can be harvested at which time. This is shared with the exporter. In the harvest programme, volumes are forecast and linked to quality forecasts at grower level.	Cooperative and exporter, the importer indirectly through the exporter
Certification	The certification serves to meet the requirements imposed from the EU. The data file certification is the result of crop registration. The certification is shared in the supply chain through the exporter.	Cooperative, exporter and the Importer indirectly through the exporter

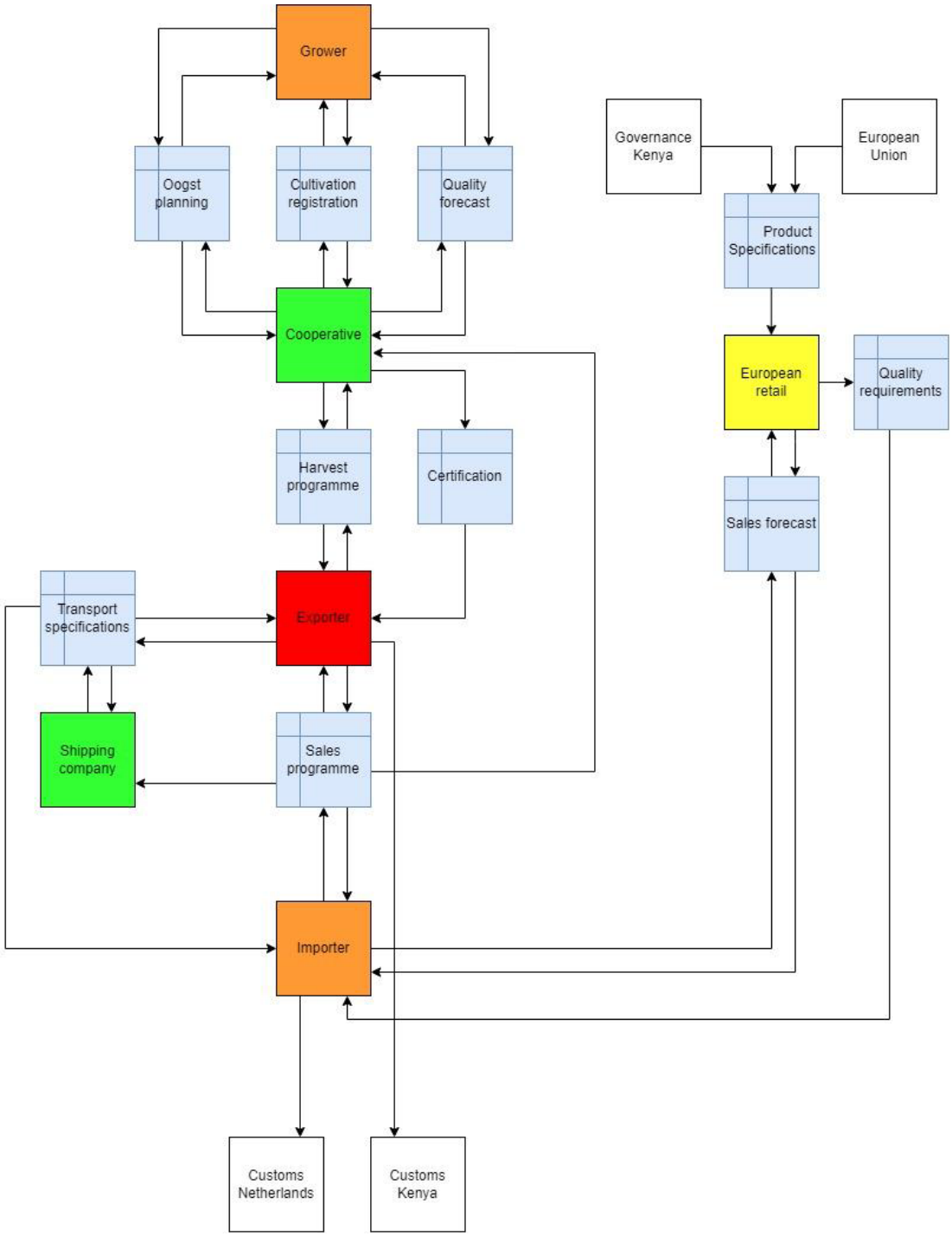

Figure 27: Design of ICT Application/Platform for avocado value chain

3.6.4 Factors Influencing the Implementation of an ICT application

It is revealed by doing a PESTEC Analysis that many may influence the implementation of ICT application in the AVC (Table 11). Understanding these, stakeholders within the chain can ascertain effective strategies to promote ICT application and strengthen the efficiency of the chain with it.

Table 11: PESTEC 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 (Mugambi, 2024). ▪ 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 (Kiera, 2024). ▪ An application cantered 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.

3.7 New technologies

3.7.1 Non-destructive measurements of avocado quality parameters (Lu et al., 2023)

Avocado with known (internal) quality can be delivered to different but appropriate markets. For instance, some low-quality avocados can be shipped to the oil industry, chips industry or for guacamole.. Classification of internal quality usually relies on a destructive testing method, which is not only unrepresentative but will also cause unnecessary waste when the large amounts need to be removed for testing. Although there is a specific correlation between fruit appearance and internal quality, this method has a high misjudgement rate. It thus cannot be implemented for some fruits and vegetables.

The development of microwave technology in the internal quality detection of agricultural products in recent years opens a door to fast and non-destructive measurement. It can detect a variety of internal components at the same time and has ten times deeper microwave sensing than Near Infrared Region (NIR) technology (Fig. 28). Therefore, the objective of this project is to investigate whether the manual measurements of avocado quality parameters can be replaced by microwave technology by doing a literature study and lab research. Due to the technical limitations, only two parameters, namely dry matter content and firmness were measured and compared between destructive and non-destructive. The firmness was measured by using a texture analyser (Fig. 28).

Fig. 28. *Left*: Fresco microwave sensor from Vertigo-Technology, Delft. *Right*: Texture Analyser XT plus.

The Partial Least Square (PLS) regression analysis on the dry matter content of avocados reveals a moderate correlation between microwave (non-destructive) and manual (destructive) measurements with an R^2 of 0.605. This indicates that the model explains 60.5% of the variability in the data. The small Root Mean Square Error (RMSE = 0.018) indicates that the average gap between the predicted and actual values is small, and the prediction accuracy is high. MAE (Mean Absolute Error) = 0.015 represents the mean absolute error between the predicted and actual values. A small value indicates a high prediction accuracy. MAPE (Mean Absolute Percentage Error) = 0.072: This means that the average error of the model's predictions is 7.2% of the actual value, a relatively small percentage error, indicating high accuracy of the model's predictions. The actual correlation is shown in Fig. 29.

In terms of the PLS regression model of firmness in avocados, R^2 = 0.656: This indicates that the model explains 65.6% of the data variability, which is a better fit than the dry matter prediction. RMSE = 2.303: This is a relatively large error value, indicating that the average difference between the predicted and actual values is large and the prediction accuracy is low. MAE = 1.841: This value is also relatively large, indicating low prediction accuracy. MAPE = 0.338: This indicates that the mean error of the forecast is 33.8% of the actual value, which is a relatively large percentage error and indicates that the model's prediction accuracy is low. The actual correlation is shown in Fig. 19.

The microwave technology has the potential to supplant conventional manual methods, yielding precise and consistent results. However, the reproducibility needs to be further verified. As well as detection of oil content and internal defects of avocados other important quality parameters of avocados also need to be tested.

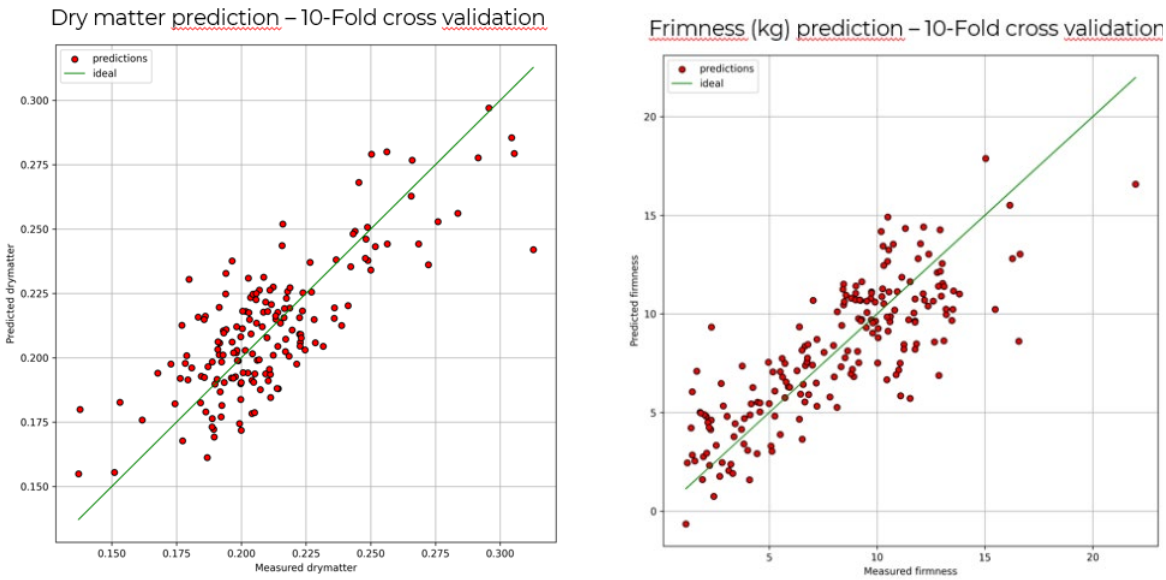

Fig. 29. Correlation between microwave (Y-axis) and manual (X-axis) measurements of dry matter content (*left*) and firmness (*right*)

3.7.2 Post-harvest handling technologies (Sun et al., 2023)

The aim of this project is to investigate whether technologies can be applied in avocados' post-harvest handling to reduce the waste and lead to a more sustainable food supply chains (FSCs) in Kenya. The study focused on four areas, namely sorting, packaging, storage, and parts of transportation (Fig. 30).

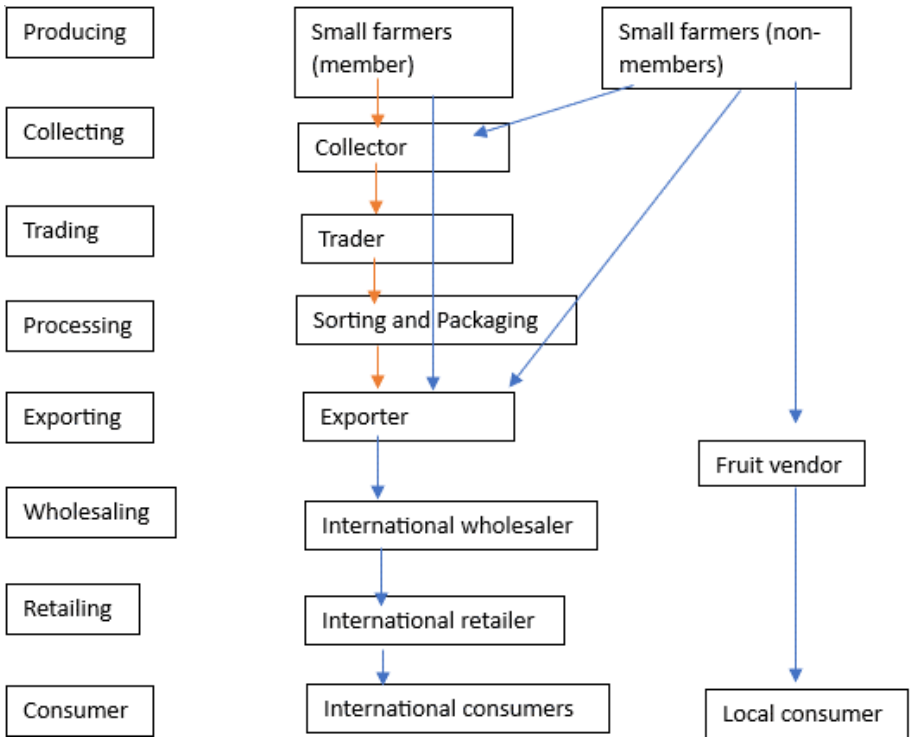

Fig. 30. The avocado supply chain in Kenya based on literature. Chain members pointed by the red arrowheads are the target groups of this study.

Causes of food loss during sorting, packaging, storage, and parts of transportation (based on literature)

It was reported that 30% of avocados are wasted because of grading errors (Cranfield University, 2020). This was mainly due to manual sorting by untrained personnel and lack of non-destructive determination of avocado internal quality and maturity. During packaging, collisions of avocado with each other or with packing boxes leading to internal damage is a major reason of waste. During storage (of fruits), the relative rate of respiration/deterioration is positive while shelf life is negatively correlated with temperature. In the production sites, most farms do not have precool facilities and leave avocados at air temperature. Also, to decrease the cost, market agents collect all avocados in the area, which may last for days. But the trucks do not have temperature-controlled systems, possibly leading to quick ripening. In addition, the lack of storage facilities in depots can also cause a significant waste. Loss or waste in transportation is one of the serious challenges in the avocado supply chain management because of the handling and deterioration of the product during transportation activities. It may result from physical damage like shaking on the road and "biochemical" damage due to high temperature.

Technologies to be used to reduce food loss during sorting, packaging, storage, and parts of transportation

Near infrared spectroscopy (NIR) may be used as non-destructive technique to measure dry matter, water and oil content of avocado. Even though, it is not easy to set a standard due to varieties and growing locations/environments. Moreover, it required more than 24 hours of injury "symptoms" to be developed before this technique can be used to detect internal injury. To avoid collisions of avocado fruits, an innovative machine was reported to slow down the falling speed of the fruit due to the improvement of the metal chute and the presence of horizontal brush rollers (Timm & Brown, 1991). In addition, spraying of preservatives and fungicides such as Prochloraz on the surface of the avocado can delay rotting of avocados, caused for instance by anthracnose disease (Colletotrichum sp.). For the same purpose, some environmentally friendly agents such as lemongrass oil and ozone are also used.

Temperature Management was estimated to help reduce 30-60% of transport and storage loss. Precooling before sending the fruits to storage is considered one of the most significant measures to maintain product quality. It can efficiently help delay of the ripening and softening after harvest. It is also called "First Mile Cooling". The recommended temperature is 16 ℃ or even lower. Ideally, avocados should be sent to the depot within 2 hours after harvest. In depots, the general temperature in storage is 5-12°C and RH is 85-95%. In terms of atmosphere, Controlled Atmosphere is useful to inhibit the ethylene by maintaining a low O_2 level and a high CO_2 level. Coating is another way to control atmosphere content. One example of this is using 1-Methylcyclopropane (1-MCP), a plant growth regulator, to inhibit ethylene synthesis and delay the onset of the climacteric peaks of CO_2 production. It also helps to, protect avocados from cold injury and promote colour development for early and middle-harvest avocados by inducing a greener colour. The other example is the combination of waxing, LDPE, and temperature, which contributes to a decrease in cold damage, minimizes quality loss, decreases metabolism and ethylene production. To solve the problem of high temperature during transportation, a small number of farmers choose to use functional smart trucks which can adjust temperature during the transportation from their farms to the depots. Monitoring and controlling the temperature, humidity, air condition etc. in the container by using sensors would be a good solution of reducing waste on the road.

3.7.3 Chemical and technology tools use impact (Habineza et al., 2022)

98% of interviewed farmers said that they grow avocados organically, using organic manure in Meru County in both high and low land regions. The control of pests is carried out using traps. With the advancement of technology, nearly 100% of professional farmers, both retired and large-scale, in the highland and lowland regions have implemented drip irrigation systems on their farms. Avocado farming regions have enough water for irrigation, especially in the highland region. Only skilled and professional farmers know the benefits of irrigating their farms. Irrigation requires much investment which small scale farmers cannot afford. Technological tools are primarily applied in the packhouse, where production is steered and processed based on international quality standards and requirements. At the farm level, however there is a gap in seedlings and production traceability technology. Dry matter content and size of avocados are measured in exporters' packhouses by using improved equipment while at the farm level, the activities are manually done.

3.7.4 Individual Quick-Freezing technology

The Individual Quick-Freezing market is expected to reach USD 23.65 billion by 2026. The benefits of this method of preparing frozen food are that the process isn't time-consuming. The exact time depends on the type of IOF freezer and the product. The short freezing prevents the formation of large ice crystals in the fruit cells, which maintains the product shape, colour, smell, and taste after defrosting. An added advantage of IQF technology is its ability to separate units of the products during freezing, which produces a higher quality product compared to block freezing. This advantage is also vital for food sustainability, as the consumer can defrost and use the exact needed quantity. (https://slideplayer.com/slide/18000304/).IQF avocado is considered as an essential way to deal with the blemish and ripeness problems. The technology is widely used in Australia frozen avocado industry (Fanning et al., 2012). The potential use of this technology is described in Chapter 3.4.

3.8 Export and import business cases

3.8.1 Export of Kenyan avocado to the Netherlands'/EU in the form of Individual Quick Frozen

As described as "new product" in Chapter 3.4, there is good market potential for Individual Quick Frozen (IQF) avocado. Most Dutch consumers considered IQF avocado as convenient food with extended shelf-life. When all the following conditions are met, the export business can be initiated. The process and transportation need to comply with the EU regulation on frozen fruits, including level of contaminants, temperature during storage and transport, CSRD (Corporate Sustainability Reporting Directive) report. In Kenya, there should be enough fresh avocado, availability of storage and processing facilities. The preferred business model is B2B.

3.8.2 Avocado export pilot

Introduction or rationale
It is Incredible what the cooperation in the chain can achieve and how impressive the export initiative of the small-scale avocado farmers from Nandi County and Meru, Mount Kenya is. The results of the FORQLAB project (https://ap.lc/oqmxB)are also impressive. 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/ business approach was chosen with farmers, companies and governmental organizations participating in the project. Interviews with avocado farmers showed that many losses occurred because of poor planning, communication and coordination in the chain. Knowledge of the chain and the market was also insufficient. The result of

the analysis encouraged growers to express their ambitions to export independently. In addition to reduction in wastage, this may also result in a higher living wages and standards. 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.

Business case pilot: Shipment to Europe
On the 14th of July 2024 the 4 cooperatives sent their first shipment in close cooperation with the project partner Airflo Ltd. to Europe and they succeeded! Despite some scepticism and prejudice locally and within 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 with future exports of their own productions. 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 within their supply chain.

Results from the pilot shipment:
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 because 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 the exporter 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.
Lenticel Issue: Lenticell is not accepted by all customers these needs further clarification.
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 flavour 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 results on a larger scale.

Conclusions
Summary
The main advantage is that the avocados were clean and had limited serious skin damage. However, the problems with mix pallets, 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 uniform ripening and delivery of avocados to the customers of the importer.

Step by step, the cooperatives need to work towards meeting the minimum export standards while demonstrating their ability to operate on a financially viable scale. The project has provided key insights into the supply chain in Kenya and has identified several crucial next steps for its development.

4. Conclusions

4.1. Understanding the value chain

In the whole value chain for avocado production in Kenya, on average, 48% of the total production is destined to become loss or waste. From the total harvest it is estimated that 25% of the fruit directly becomes loss or waste. The biggest proportion of this waste (49%) occurring during the processing and packaging, the remainder in collection and storage (26%) and distribution (25%).

The chain can be broadly divided into two distinct production flows; one coming from large scale more centralised enterprises aimed at the export market, the other, which is the more dominant production flow, is geared to the local market and consists of small scale and fragmented producers. In the latter group, cooperatives play a pivotal and central role in the business transactions and dissemination of information. Accessibility and consistency in the services the cooperatives can provide still remain limited given the challenges in infrastructure and fragmented nature of the production. This chain therefore is complex given that small scale growers rely on several channels to sell and market production.

Within the two regions studied Meru and Nandi, it was found that most growers (members are non-members) sell their produce through the cooperatives. A significant number however of the small cale sector still sell through middlemen or brokers. Here transactions at the farm gate are dominant and the growers have little leverage over price. In all production flows it was evident that the time constraints with this perishable product was challenging given the local (cooling) infrastructure and resources.

4.2 Technical Interventions to reduce food losses of avocado in both local and export-oriented food systems

ICT is critical within supply chains for traceability management, communications and data management. Within the small-scale sector communications are only used for administrative purposes and do not drive actor decisions. Although mobile networks cover most of the production area, very few growers have smart devices. For safety, ethical and sustainability compliance, traceability is essential to access export markets.

Given the fragmented nature of small sector, traceability stops at the farm gate. However, at regional level, there are signs of various ICT platforms developing which could be utilised by the cooperative networks. Blockchain IT systems, Internet of things – sensors and cloud computing systems were all identified as important developments which could have a dramatic influence within supply chain. In the survey for readiness to adopt these technologies, it was identified through various actors in the chain that many political, social and economic challenges still need to be addressed. In conclusion a realistic approach to development and integration of ICT would be a hybrid system where solutions are found to integrate innovation in ICT with local technology and systems being used.

Post harvest technology is developing fast. The development of microwave technology for internal quality detection in agricultural products offers a fast and non-destructive measurement method, potentially replacing conventional manual methods. Kenya can also learn from the implementation of other technologies being applied in the world market. Such as innovative machines to prevent

collisions, and the use of more sustainable and natural preservatives like lemongrass oil. Additionally, the Individual Quick Freezing (IQF) global market is expected to reach USD 23.65 billion by 2026. This should be included as a potential market for Kenya given that it offers a time-efficient, high-quality preservation option.

Many gains can also be made from low tech innovations in cold chain management. Temperature Management was estimated to help reduce 30-60% of transport and storage loss. Precooling before sending the fruits to storage is considered one of the most significant measures to maintain product quality. Monitoring and controlling the temperature, humidity, air condition etc. in the container by using sensors would be a quick win in maintaining product quality and reducing waste on the road.

4.3 **Governance interventions to encourage safe products and reduced food losses of avocado in both local and export-oriented food systems.**

In the small-scale sector, a significant amount of wastage can be directly attributed to a lack of knowledge. Cooperatives engage with several government agencies for extension services and technical support. These agencies provide essential inputs for the chain, such as certified planting material and guidelines on food safety. However, resources from these agencies are limited, leaving many growers excluded or unaware of these services. The study showed that many younger farmers and women are directly involved in avocado cultivation and need access to cooperative services and knowledge agencies.

Due to contractual relations, wholesalers often accept more supply than the actual market demands, leading to incorrect storage and wastage. Divisions in the chain are often created through conflicts over pricing, with short-term gains being the major driver for producers. Better communication between wholesalers and retailers is therefore essential. Improved coordination between these actors can lead to better quality predictions, allowing for a longer shelf life and reduced waste. While collaborations are evident between actors within the Kenyan chain, mechanisms to facilitate information flow are not yet fully developed. Here, developments in ICT can play a pivotal role.

5. Recommendations

Recommendations are made based not only on the outcomes of all the individual reports but also based on the new developments in the public domain when this report was being written.

5.1 Production

5.1.1 Cultivation

- Move from silvicultural to pomological practices.
- Use certified seedlings with good quality.
- Implement integrated pest management practices.
- Keep records at farm level to track farming activities. This information may be used to create a kind of passport for the fruits from each grower. It is also important for both the cooperative and the next links in the supply chain.
- Train the farmers on cultivation, crop protection and judgement on the quality and maturity of avocado fruits. During harvesting, growers must be able to distinguish between 1e and 2e class avocados.
- Use specialized harvesting teams.
- For growers to be GlobalGAP certified for producing avocado for the EU markets.
- To be divided into different regions according to altitudes of plantations to ensure a homogeneous product as well as harvesting time.

5.1.2 Post-harvesting

- Collect the avocados immediately as soon as they are harvested.
- Establish and optimize low-cost temperature-controlled aggregation facility to maintain the quality and shelf life of the avocado meant for both export and domestic market.
- Establish an efficient cleaning process, sorting and packing of the fruits.
- Introduce Agro-processing facility to extract avocado oil (so as to reduce loss & waste).

5.1.3Export and import

- Try to shorten the lead time to the exporting harbour to the importing harbour.
- Use cold chain when possible.

5.1.4The chain

- Strengthen chain coordination to improve the robustness and stakeholder capacity to improve and increase market access.
- Renew the business model from individual business to business entities regarding avocado marketing, processing and good quality and licensed Hass avocado seedlings.
- Popularize value chain governance to strengthen the partnerships among the various stakeholders in the value chain.
- Specifications of the chain:
    - Average lead time from harvest to port Mombasa: <5 days;
    - Average transit time Mombasa to Rotterdam: <30 days;
    - Delivery rate to retail: >99.7%;
    - Avocado turnover at importer: <12 days;
    - Avocado turnover at retail: <6 days
- Add technology Intervention in the agenda (ICT, non-destructive internal quality determinations, packaging and processing, etc.)

5.2. ICT applications

The key steps for developing ICT applications may be as follows:

- Project Initiation and Requirements Analysis: This involves detailed research on the value chain, prioritizing the list of desired information, and an in-depth assessment of users' needs.
- Initial Meetings: Conduct one or two meetings with the client to gather detailed information about the supply chain process. Also, a meeting with the developer(s) to relay the requirements and agree on a design.
- Value (Supply) Chain Mapping: A visual representation of the avocado value/supply chain is illustrated identifying key steps and potential areas for improvement.
- Solution Design: Based on the mapping, the design of a potential solution that addresses the client's needs and is cost-effective.
- Cost and Time Estimation: Preparing a cost estimate for the proposed solution.
- Wireframing: This is the preliminary stage of design creating representations of the user interface. Essentially, it is the blueprint of the application and is often sketched with simple tools focusing on the layout, structure, and app functionality without going into the visual design elements. It can take two weeks.
- Coding (Developing): This involves the programming stage. It can take two weeks or more.
- First (Pilot) Testing: A small-scale testing is conducted internally with the value chain expert and the developer.
- Second Testing (Validation): The value chain experts, the KALRO content team, the agricultural officers, selected farmers, agro-dealers, or agri-tech carry this out.
- Iterative Improvement: Gathering feedback from the pilot and validation, refining the solution, and expanding its implementation.
- Full-Scale Deployment (Launch): Once the solution proves effective, it is rolled out to all relevant stakeholders.

5.3. Food Loss Waste reduction interventions (WUR)

The following web-based tools released by the WUR may be used when thinking about potential approaches to reduce food loss and waste (FLW).

On 27 Sept. 2024, WUR launched the website food-loss-solutions (ACT: Designing FLW interventions (wur.nl)). In this website different tools for targeting and measuring FLW as well as tools for FLW reduction interventions are shown in three modules, namely TARGET, MEASURE and ACT.

TARGET is about identifying which food products, countries, regions or supply chain stages have the most impact on achieving Food Loss and Waste (FLW) reduction. By focusing on the right options, impacts can be maximised across multiple areas simultaneously. In this module, Global Food Loss and Waste hotspots can be identified, Food Loss and Waste country profiles and Food Loss and Waste product factsheets can be found.

MEASURE is a quantification tool, containing different methods of measurement. By using this tool the relevant choices in a FLW quantification approach can be made step by step. Meanwhile preferences can be adapted in time and costs, and get insight in the pros and cons of these considerations.

ACT is for designing FLW interventions. To obtain real impact on Food Loss and Waste investments, it is necessary to design Food Loss and Waste (FLW) interventions guided by evidence-based insights for your specific situation. Via the intervention, the following can be revealed:

- at what stage FLW occurs

- why it occurs
- how much FLW is occurring within the specific value chain, product group or country to be focused on

Designing FLW intervention include:

- Mapping out your own intervention – FLW intervention design canvas
- Assessing and design interventions
- Assessing impacts and trade-offs
- Stakeholder mapping for effective partnerships - interest and influence matrix
- Revalorization interventions

Temperature
- It is important that avocados are chilled back as soon as possible. Harvesting and then cooling should take place on the same day.
- It is important not to refrigerate the avocados back too quickly.
- Avocados should be refrigerated at 6°C to 7°C.
- A temperature recorder should be placed in the container during transport of the avocados.
- Beware of refrigeration damage to the product.

Container settings
- Temperature 6°C.
- Controlled atmosphere 4% O2 and 6% CO2.
- Humidity between 85% and 95%
- Ventilation off
- The air system must be kept clean.
- There should be cardboard in front of the last pallets. This means the air must go up through the avocados and cannot go up through the back near the doors.

Packaging and pallets
- Packaging must meet hygiene, ventilation and sturdiness standards.
- Each package must contain the requested weight on arrival.
- Each pallet should have a sticker on it showing the number of crates on the pallet.
- There must be a label on each crate

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Appendix 1. Student reports cited and used in compilation of this report.
Full text of these reports can be sourced through [FORQLAB student research on avocado loss and quality | NFP Connects]

Original idea (Ch. 2)	Report Titel	Student	Supervisor	University
Research Area - Avocado value Chain (AVC)				
g, i	Enhancing information exchange in the Kenyan Avocado Supply Chain	Jiayin Fan, Kaifeng Pan, Michael Rensen, Zhenglai Zhu	Wendy Martin	Inholland
g, i	Reducing the waste of fresh avocados from Kenya into the Netherlands by using the Iceberg model	Jianing Zhu	Marinus van Haaften, Woody Maijers	Inholland
	Scaling mechanisms for avocado loss reduction in Meru County, Kenya	Angela Atieno Onyango	Albertien Kijne, Rik Eweg	VHL
g, i	Sustainable Sourcing - Development of Traceability in the Kenyan avocado value chain for small- and medium scale farmers	Dafa Witoelar, Sander Duijghuisen, Bertken de Leede		HAS
g, i	Business- and implementation plan container transport for Kenyan avocado	Gerco Duister, Bart van Haaren, Imke Noordman		HAS
g	Reduction of Food losses along the Meru avocado value chain in Kenya	Harriet Asekenye	Euridice Leyequien, Petros Maliotis	VHL
Research Area: Food loss audit (Understanding the rationale behind the avocado waste in the export chain)				
g, i	Food Loss and Waste in the Avocado Supply chain Kenya - Europe	Diederik Houben, Henk de Glopper, Ramon Wagenaar	Peter Bouma, Rolf Kerkhof Mogot	HAS
	Analysis of Food Loss and Waste in Avocado Value Chain: A case study of Avocado Value Chain among the smallholder farmers in Nandi County, Kenya	Elizabeth Ayuma Okech	Peter van der Meer, Albertien Kijne, Peter Bouma	VHL
g, i	Reducing the waste of fresh avocados from Kenya into the Netherlands by using the Iceberg model	Jianing Zhu	Marinus van Haaften, Woody Maijers	Inholland
g	Reduction of Food losses along the Meru avocado value chain in Kenya	Harriet Asekenye	Euridice Abarca, Petros Maliotis, Eric Mworia	VHL
Research Area: Product Quality				
h	Introduce Kenyan Frozen Avocado to the Netherlands	Xiaoyi Zhang	Caicheng Huang, Woody Maijers	Inholland
c	Fresco Microwave - A non-destructive method to measure the quality parameters of avocados	Yatao Lu	Caroline Elfferich, Caicheng Huang, Woody Maijers	Inholland
Research area: New products				
h	Introduce Kenyan Frozen Avocado to the Netherlands	Xiaoyi Zhang	Caicheng Huang, Woody Maijers	Inholland
d	Finding the right product-market fit for avocados from the Nandi cooperative	Tijmen Droog, Tom Engels		HAS
	Reduction of waste avocados in Kenya	Nicolas Burger, Tijn van Staalduinen, Maureen van der Berg		HAS
Research Area: Chain Governance				
a	The Potential Contribution of Value Chain Governance in the Reduction of Avocado Production Losses Case of Abogeta West	Jean Pierre Habineza	Rik Eweg, Robert Baars, Eric Mworia	VHL

	Growers' cooperative association Ltd, Meru County, Kenya			
Research Area ICT Applications				
f	ICT readiness assessment for an integrated chain-wide traceability system: A case study of the avocado value chain in Nandi County, Kenya	Cynthia Moraa Onyangore	Geert Houwers, Marco Verschuur, Woody Maijers	VHL
g, i	Food Loss and Waste in the Avocado Supply chain Kenya - Europe	Diederik Houben, Henk de Glopper, Ramon Wagenaar	Peter Bouma, Rolf Kerkhof Mogot	HAS
	Improving Communication and Coordination through an Information and Communication Technology (ICT) Application within Avocado Cooperatives in Meru County, Kenya	Kareemat Opeyemi Fakorede	Albertien Kijne, Arno de Snoo	VHL
	Leveraging an Information and Communication Technology (ICT) application to enhance Communication and Coordination within Nandi Avocado Farmers' Cooperative Society	Mercy Moraa Mairura	Albertien Kijne, Ghislaine Bongers	VHL
Research Area New Technologies				
f	Reduction of Food Waste of Avocado During Post-harvest in Kenya by Applying Technology	Yatao Lu, Xiuwen Wang, Di Sun, Meihao Xie, Xiaoyi Zhang	Wendy Martin, Woody Maijers	Inholland
f	Fresco Microwave - A non-destructive method to measure the quality parameters of avocados	Yatao Lu	Caroline Elfferich, Caicheng Huang, Woody Maijers	Inholland
Research Area: Export and Import business cases				
	Introduce Kenyan Frozen Avocado to the Netherlands	Xiaoyi Zhang	Caicheng Huang, Woody Maijers	Inholland

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