

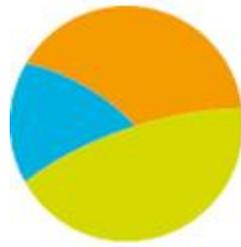
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**ICT READINESS ASSESSMENT FOR AN INTEGRATED CHAIN-WIDE TRACEABILITY  
SYSTEM:  
A CASE STUDY OF THE AVOCADO VALUE CHAIN IN NANDI COUNTY, KENYA**

**Submitted by:  
Cynthia Moraa Onyangore  
September 2022**

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**Thesis submitted in partial fulfilment of the requirements for Master of Agricultural Production  
Chain Management (APCM) – Horticulture Chains Degree**

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

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# **DEDICATION**

This thesis is dedicated to my mom, Martha Onyangore, for her unconditional love and support and for helping me remain centered when I get flustered. I also honor the memory of my late Dad, Benedict Onyangore Onyonka and his role in shaping my career pursuits.

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# LIST OF ABBREVIATIONS AND ACRONYMS

AI	Artificial Intelligence
APCM	Agricultural Production Chain Management
APEAM	Association of Avocado Exporting Producers and Packers of Mexico
BMC	Business Model Canvas
CBI	Center for Promotion of Exports from Developing Countries
CCP	County Connectivity Project
EU	European Union
F2F	Farm to Fork
FAO	Food and Agriculture Organization
FORQLAB	Food Waste Reduction and Food Quality Living Lab
FSC	Food Supply Chain
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GOK	Government of Kenya
HCDA	Horticultural Crops Directorate Authority
IBM	International Business Machines Corporation
ICT	Information and Communication Technologies
IFPRI	International Food Policy Research Institute
IoT	Internet of Things
IPM	Integrated Pest Management
JICA	Japan International Cooperation Agency
KALRO	Kenya Agricultural and Livestock Research Organization
KEPHIS	Kenya Plant Health Inspectorate Services
KNBS	Kenya National Bureau of Standards
MRL	Maximum Residues Limits
NARIG	National Agricultural and Rural Inclusive Growth
NOFBI	National Optic Fiber Backbone
NRI	Network Readiness Index
ODIS	Organizational Development and Institutional Strengthening
OKP	Orange Knowledge Programme
PPPs	Public Private Partnerships
SDG	Sustainable Development Goals
SPS	Sanitary and Phytosanitary
TLBMC	Triple Layered Business Model Canvas
ToC	Theory of Change
UAE	United Arab Emirates
UN	United Nations
UNESCO	United Nations Educational Scientific and Cultural Organization
VCA	Value Chain Analysis
WCDI	Wageningen Center for Development Innovation
WEF	World Economic Forum

# ABSTRACT

Kenya is among the top ten avocado exporters in the world and the top exporter in Africa. There is a rising demand for good quality avocados in the domestic market in Kenya and globally. Food safety is also increasingly becoming a big concern for consumers of fresh food in local and domestic markets. Global standards in food safety have seen stakeholders in food chains become more cognizant of the need to have tracing mechanisms in the food value chains. This then, calls for increased joint efforts to improve quality, improve reputation and gain access to wider markets. ICT based solutions have been hailed as having an important role in developing integrated traceability solutions that include all the processes and stakeholders in value chains.

This study was carried out as part of the FORQLAB (Food Waste Reduction and Food Quality Living Lab) project. The project's objective is to contribute to structural reduction of post-harvest and food losses and food quality improvement in the Kenyan avocado value chain via the application of technical solutions and tools as well as improved chain governance competencies. The specific focus of this study was the assessment of the readiness of stakeholders in the local and export oriented avocado chain in adopting integrated ICT based traceability solutions. It also made an inventory of the various ICT technologies that can be used to develop an integrated traceability system. Other focus areas of the study included understanding the value chain and governance structure of the avocado chain. The study area was Nandi County, Kenya.

A social constructionism framework was used to carry out this qualitative research to allow for in depth collection and investigation of data. Data collection methods included desk studies, a case study analysis of the successful traceability system in the avocado value chain in Mexico and semi-structured interviews with various stakeholders in the avocado value chain. Business partners in the FORQLAB project were also interviewed to draw insights into best practices in the avocado value chains.

The study was modeled on a conceptual framework that combined the Network Readiness Index, Value Chain Analysis, and the Triple Layered Business Model Canvas. These allowed for an in-depth examination of the current value chain and business model and the readiness in adopting integrated ICT based traceability solutions by various stakeholders in the chain. The data collected was analyzed using Atlas.ti using the core process of identifying themes that address the research questions. Analysis of interview transcriptions revealed 10 main readiness assessment criteria, narrowed down to 5 for the Nandi avocado value chain. These included data, internet connectivity, partnerships and collaboration, regulatory environment, and future/emerging technologies.

The study concluded that there are existing and emerging technologies that can be used to develop an integrated ICT enabled traceability system. These include existing solutions like SokoFresh, UjuziKilimo and GTNet by TraceSoft and emerging technologies like Blockchain and IoT sensor technology. These would be used in a hybrid format with information being shared in Cloud based solutions like Amazon Web Services and accessed by users via a user interface like an App.

To ensure the development, adoption and implementation of an integrated ICT enabled traceability, two pronged interventions were proposed: technology intervention and value chain governance intervention. An integrated ICT enabled traceability system in the Nandi avocado value chain would have the overall impact of reducing food loss and wastage and ensuring improved prices and livelihoods for farmers.

# CHAPTER ONE

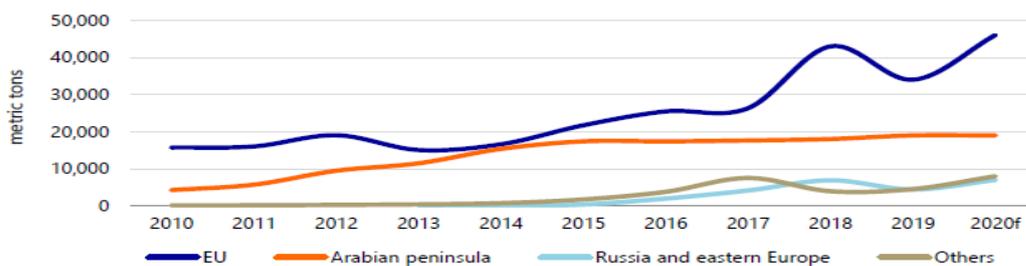


# CHAPTER 1 INTRODUCTION

## 1.1 Avocado Sector in Kenya

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

Figure 1: Kenya's avocado exports by destination



Source: Rabobank Research (2020)

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

### 1.1.1 Traceability in Agriculture Chains

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

Montet and Dey (2018) document various cases in traceability with the earliest case of traceability being documented in 1275, to trace the origin of infection of an ewe sheep by both sheep pox and mange. They further note that traceability gained attention in 1996, following the mad cow crisis in Europe. This led to the European Food law 178/2002 that was implemented in the European Union on the 1st of January 2005. This law required for all businesses to trace food and all feeds through all stages of the food supply chains including the people and systems in place.

According to the European Union (2002) the EU General Food Law defines traceability as the ability to trace and follow a food, feed, food-producing animal, or substance intended to be, or expected to be incorporated into food or feed, through all stages of the food supply chain (Olsen and Borit, 2013).

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

(Snel et al., 2021). Rampa & Dekeyser (2020) also note that avocado farmers have little or no collaborative efforts leading to inadequate information flow and transparency in chain.

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

In a study for SNV, Chemeltorit et al (2018) note that for a traceability system to effectively provide food safety and quality assurance, all value chain players commit and participate actively, information and data is shared freely, and there should be value for money so that there is a return on the investment. This, therefore, emphasizes the need for a traceability system to meet the needs of stakeholders in the value chain.

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

Mizzi, L (2019) notes that digitalization will enhance agricultural practices in Africa by allowing for food safety within the confines of sustainable agricultural practices. He further reiterates the need to have technology solutions that are tailored for specific needs and are integrated into other innovation systems.

## 1.2 Problem Context

Whereas large scale producers of avocados in Kenya are able to meet the stringent requirements required to enter export markets, smallholder producers of avocados are not able to meet these requirements and hence remain locked out of the export market. The requirements to enter export markets include complying with SPS (sanitary and phytosanitary standards), having traceability mechanisms, and having certifications confirming GAP (good agricultural practices). For domestic markets, the increase in consumer awareness and demand for good quality avocados means that smallholders not able to produce avocados meeting the local standards are also not able to effectively participate in the local value chain. In Kenya, a few large companies still control the avocado export market.

Amare and Wilson (2020) in a study for International Food Policy Research Institute (IFPRI), note that the major exporters of avocado in Kenya are Vegpro, Kakuzi, Sunripe, Kenya Horticultural Exporters and East African Growers. The study notes that although 70% of avocado production is by small holders and sourcing of avocados by these companies is from smallholders, these smallholders still face barriers to exporting including inadequate access to technologies in the chain and institutional support. Chemeltorit et al (2018) note that traceability is still confined to these large-scale exporters, locking out smallholders from effectively participating in the domestic and export markets.

CBI (2022) stipulates the following as quality requirement for fresh avocados of all classes. Avocados must be:

- Intact
- Clean and sound
- Pest free
- Damage free
- No abnormal external moisture
- Have a stalk no longer than 10mm in length
- Able to withstand transport and handling procedures

In addition, importers that ripen avocados require that avocados have 23% dry matter as a minimum, with maturity uniform throughout a batch. This is because immature avocados cannot ripen. Gema et al (2018) note the opportunity to link the domestic and export market by ensuring all produce in the value chain is complying to food safety and quality standards. This is because, some fresh produce that is export ready can be channeled into the local market, especially in urban centers. According to the CBI (2022), compliance issues create many challenges in Kenya as many exporters source their avocados from smallholders. This poses marketability challenges for the fruit.

The time lag from harvest to arrival at the EU market is also longer for Kenya, compared to the other exporting countries. This is due to inadequate shipping options, especially for smallholder producers of avocados. To synchronize the logistics gap, from farm to fork, for both the local and export market, there needs to be a traceability system that links all the stakeholders, processes, products, and information flow along the value chain. This is the gap presently existing in the avocado value chain in Kenya.

### 1.3 Problem Statement

While technology solutions exist in all the industries across the supply chain for agricultural products, they operate in isolation and do not address the key stakeholders' needs. For example, solutions that address cooling or logistics tracking do not provide visibility to the supplier and buyer. In some cases, processes, and systems of one stakeholder do not align with those of another, within the same food value chain. Technology solutions in a value chain should also be supported by a workforce with the requisite competencies. Different stakeholders in the supply chain should also be included in different technology solutions available or developed. Technology solutions that are not supported by the chain stakeholders, systems, controls, and expertise in managing them are not well integrated among all the stakeholders and processes in a food supply chain.

This fragmentation does not provide a holistic view of the end-to-end supply chain metrics and accountability system which overall increases the cost to deliver for the seller and introduces variance in the safety assurance and quality of the products delivered. Ben-Elia et al. (2014) note that fragmentation in ICT means that activities are subdivided into smaller components and are performed at different locations or timings. WEF (2018) notes that traceability at all levels in food value chains, supported by ICT and coupled with all stakeholders collaborating, will have a great and positive impact on food supply chains.

Karippacheril et al (2017) note that the capabilities of developing countries must be carefully considered when adopting traceability systems. Examining such capabilities allows for the assessment of a country's readiness in adopting such systems. This allows for identification of

bottlenecks, resources available or lacking, farm to fork chain logistics and other factors that may facilitate and/or militate for/against the adoption of traceability systems in value chains.

This study aimed at assessing 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 and increased food safety and linkages to local and domestic markets.

## 1.4 Research Objective

The objective of this study was to assess the readiness in adopting integrated chain- wide ICT based traceability solutions in the local and export oriented avocado value chain (s) in Nandi County, Kenya.

## 1.5 Research Commissioner

This study was commissioned by the Food Waste Reduction and Food Quality Living LAB (FORQLAB) Project and the Nandi Avocado Cooperative Society. The overall objective of the FORQLAB project is to contribute to structural reduction of post-harvest and food losses and food quality improvement in the Kenyan avocado value chain via the application of technical solutions and tools as well as improved chain governance competencies.

The distinct focus of this study was to assess the readiness of avocado chain actors in adopting integrated ICT based traceability solutions and make an inventory of ICT solutions that can be implemented, chainwide to allow for traceability in the avocado chain. The study assessed the readiness for both the domestic and export oriented avocado markets.

## 1.6 Research questions

### 1.6.1 Main Research Question

**What Information and Communication Technologies (ICT) tools can be used to develop an integrated traceability system in the avocado value chain in Nandi County?**

### 1.6.2 Sub questions

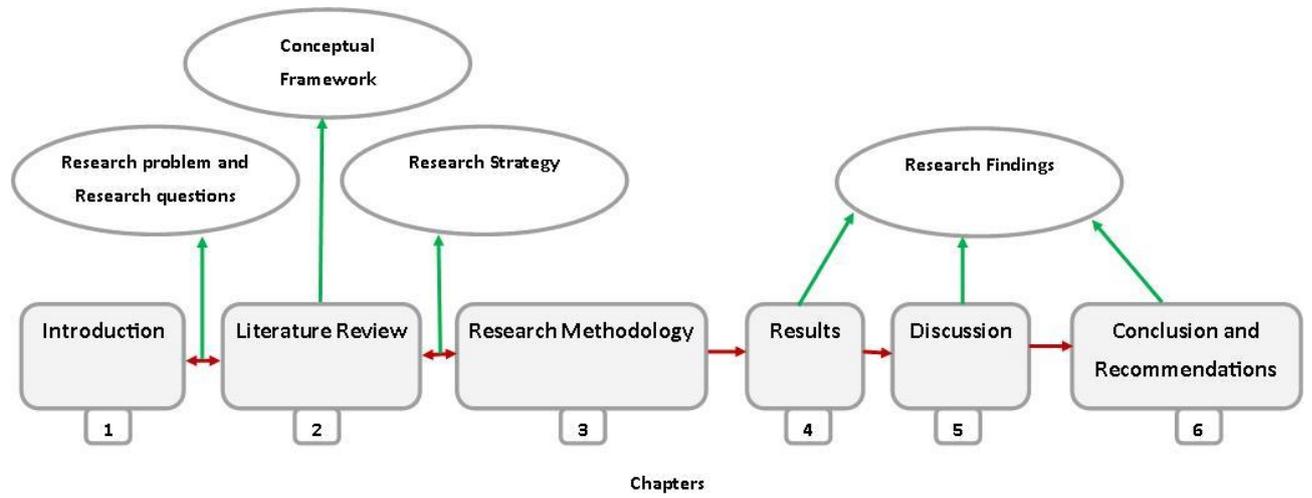
1. What are the responsibilities, interests and power of the various actors, supporters, and influencers in the avocado value chain in Nandi County?
2. What is the governance structure of the avocado value chain in Nandi County in supporting ICT readiness?
3. What ICT solutions are currently being used for traceability in the avocado value chain?
4. What is the level of preparedness among the value chain stakeholders in the avocado value chain in adopting ICT for traceability?

## 1.7 Thesis Structure

This thesis comprises 6 chapters. Chapter 1 lays an introduction to the study culminating in problem definition and the research questions. Chapter 2 forms the theoretical framework for the study by examining various facets relating to ICT, traceability, and their linkages in conducting the study. It develops the conceptual framework on which the study is based. Chapter 3 details the research methodology. In Chapter 4, the results of the study are presented and discussed in Chapter 5. In

Chapter 6, the main research is answered, and recommendations are given in line with the research objective. This is highlighted in Figure 2.

Figure 2: Schematic Thesis Structure



Source: Author's compilation

# CHAPTER TWO



# CHAPTER 2 LITERATURE REVIEW

This chapter reviewed literature pertaining to concepts relating to the research topic and questions. The main concepts for this study are ICT, value chain and traceability. The literature review also laid the basis for the conceptual framework for this study.

## 2.1 Defining Concepts

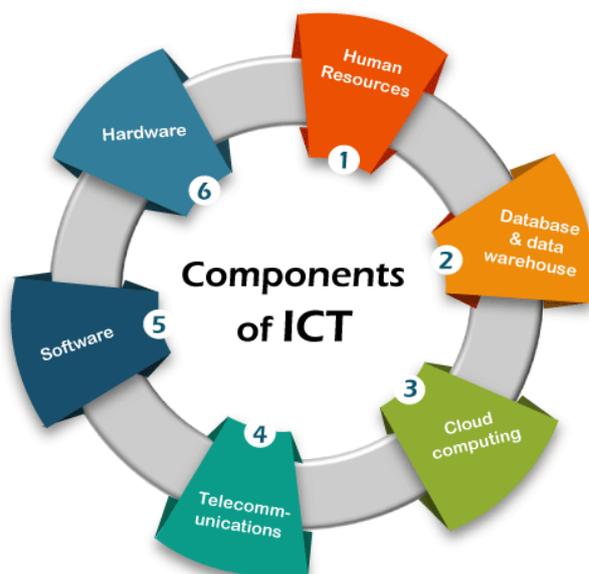
These are the important terminologies that define the concepts and research focus areas for this study.

### 2.1.1 Information and Communications Technologies (ICT)

UNESCO (2017) defines Information and communication technologies (ICT) as a set of technology tools and resources used to manage information. These technological tools and resources include computers, the internet, live broadcasting technologies, recorded broadcasting technologies (podcasts and storage devices) and telephony (fixed or mobile, satellite, videoconferencing, etc.). Java T Point (2022) also note that ICT has been used in agriculture in ways like advisory services to farmers, statistical data gathering and traceability.

The various components of ICT are represented in Figure 3. To have an effective system, it is imperative that all these different components are addressed by an organization.

Figure 3: Components of ICT



Source: <https://www.javatpoint.com/> (2022)

### 2.1.2 Digitization

According to Bloomberg (2018) digitization is the process of changing from analog to digital forms. What is digitized, is the information, not the processes. Beer et al (2021) note that digitization is an important precursor for the other levels of the shift to ICT.

### 2.1.3 Digitalization

Digitalization is the use of technologies to change a business model, provide new revenues, and value propositions. It is the process of moving to a digital business. It's the process of employing ICT to transform business operations (Hanninger et al., 2018)

### 2.1.4 Digital Transformation

Ebert and Duarte (2018) define digital transformation as using disruptive technologies to increase productivity, value creation and social welfare. They also note that use of cognitive computing has expanded digital transformation in such areas as precision agriculture and logistics. A contributor in Tech Target (2022) notes disruptive technologies take the place of already existing technologies and changes the way in which an industry operates.

### 2.1.5 Traceability

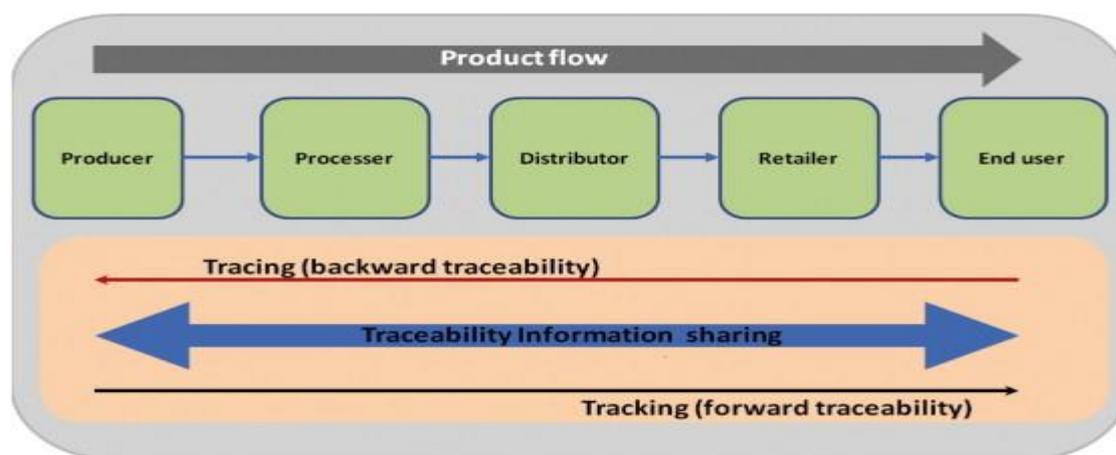
According to the European Union (2002) The EU General Food Law defines traceability as the ability to trace and follow a food, feed, food-producing animal, or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing, and distribution. (Olsen and Borit, 2013).

EIT Foods, the world's largest and most dynamic food innovation community, is an initiative funded by the EU to create partnerships between different stakeholders in food systems. EIT Foods (2021) defines digital traceability as the capability to digitally identify and trace the origin, movement, placing, and application of a product to ensure the reliability of claims concerning sustainability, in the areas of people's rights, labor (including health and safety) and ecological and anticorruption.

This definition by EIT Foods broadens the meaning of traceability from the flow of food in the supply chain, to other food systems boundaries including sustainability and will be adopted for this study.

Figure 4 shows traceability in food supply chains.

Figure 4: Traceability information flow in food supply chain



Source: Bosona and Gebresenbet (2013)

### 2.1.6 Value Chain

Vermeulen et al (2008) in developing strategies for chainwide learning for multistakeholder processes, note that a value chain includes all the activities that are undertaken in transforming raw materials into a product that is sold and consumed. These include the direct functions of primary production, collection, processing, wholesaling, and retailing, as well as the support functions, such as input supply, financial services, transport, packaging, and advertising.

Neven (2014) defines a value chain as all the stakeholders and their coordinated value-adding activities that produce raw materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has benefits for society, and conserves natural resources. This definition of a value chain considers the chain

activities, as well as the 3Ps of sustainability (people, profits, planet), hence giving a comprehensive overview of the value chain within the food systems boundaries. This is the definition adopted for this study.

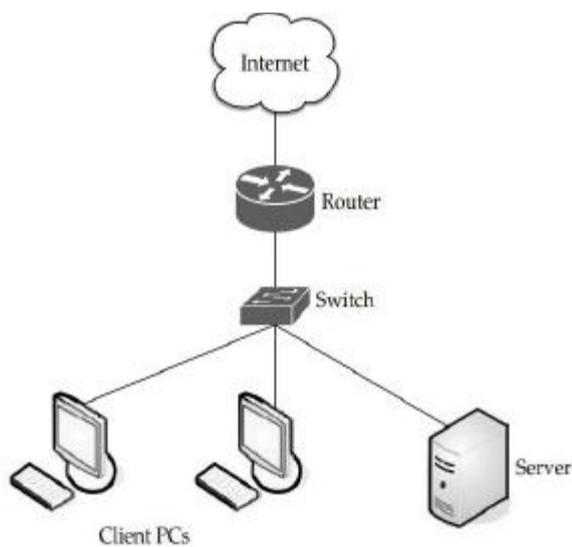
### 2.1.7 Business Model

Osterwalder (2005) defines a business model as the ways on how an organization creates, delivers, and captures value. It is how a business earns revenue, while delivering value for its clients.

### 2.1.8 Cloud Computing

Rashid and Chaturvedi (2019) define cloud computing as storing and gaining access to data over the internet instead of people's computer hard drives. Users are then able to retrieve files and use applications from any device with internet connectivity. Gmail, by Google is an example of a cloud computing provider. This is the definition adopted for this study. This is illustrated in Figure 5. In a cloud computing framework, users do not need to purchase or own the infrastructure they require e.g. servers to store data; rather, they only pay for the resources they utilize. Malik et al (2018) note the cost savings as users do not need any running or installation costs for the software or hardware and the ease in accessing data by different users from different locations.

Figure 5: Cloud Computing Network



Source: Rashid and Chaturvedi (2019)

### 2.1.9 Open-Source Software

Fortunato and Galassi (2021) define open software as a computer program released under a license and gives users the rights to run the program for different purposes, modify it and redistribute it either in its original or modified format. The reverse of open software is proprietary software, which means software not available to be customized. For purposes of this study, this is the definition adopted.

## 2.2 Food traceability in value chains

WEF (2019) notes the needs for a paradigm shift in food systems to ensure enough safe food is being produced for all, in sustainable ways. Some of the transformative technologies that can be used in food systems are highlighted in Figure 6.

Figure 6: 12 Transformative Technologies in Food Systems



Source: World Economic Forum (2018)

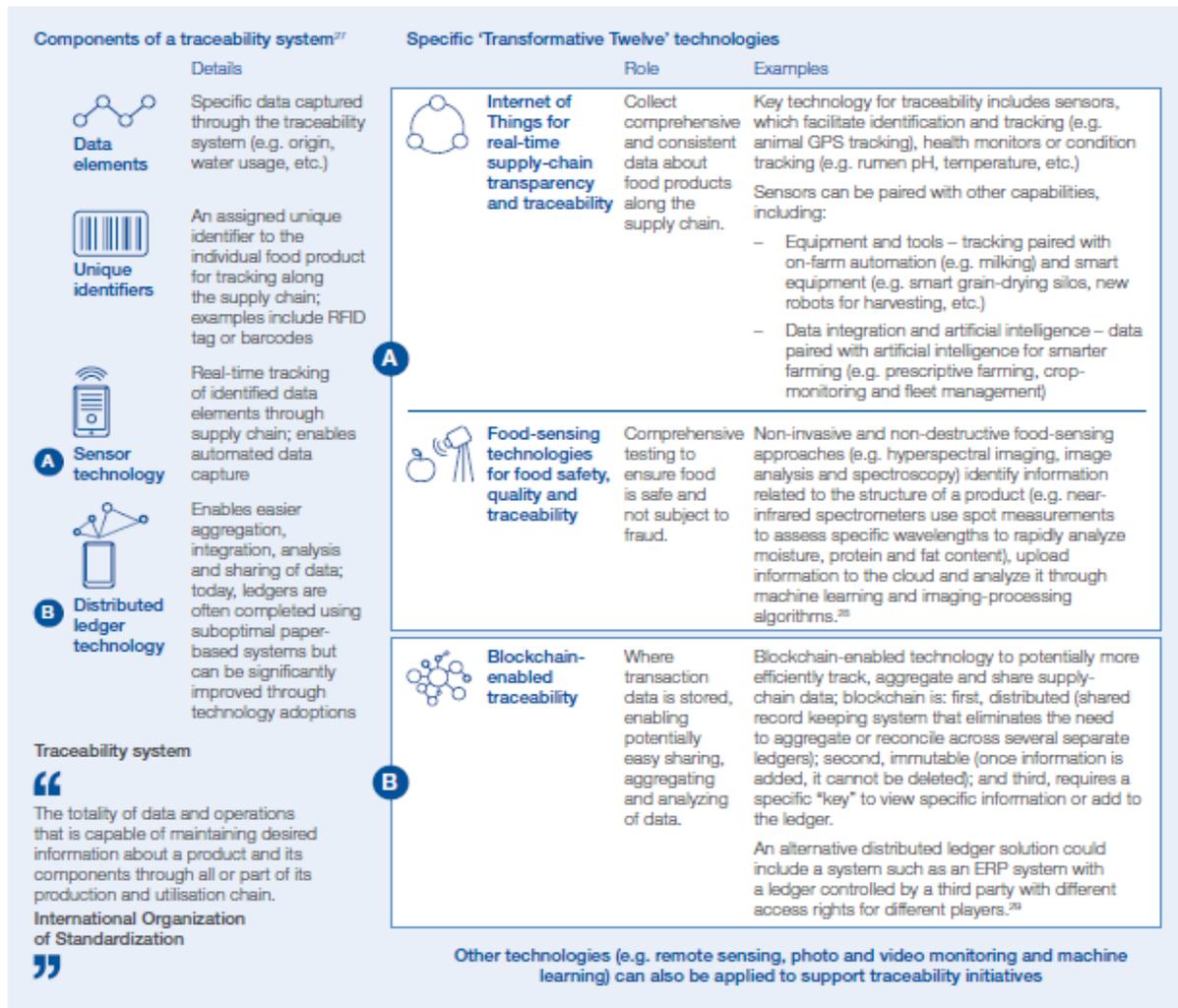
These 12 transformative technologies are cross-cutting along the value chain processes and include all stakeholders in these value chains. A traceability system needs to be end-to-end, from farm to fork, from producer to consumer. This requires a traceability system to have some specific components. These include data elements, unique identifiers for products, sensor technology and distributed ledger technology. (WEF, 2018)

Specific transformative technologies that can be used include:

- Internet of Things (IoT)
- Food – sensing technologies
- Blockchain

The various components and transformative technologies for traceability are highlighted in Figure 7.

Figure 7: Traceability system and Transformative Technologies



Source: World Economic Forum (2018)

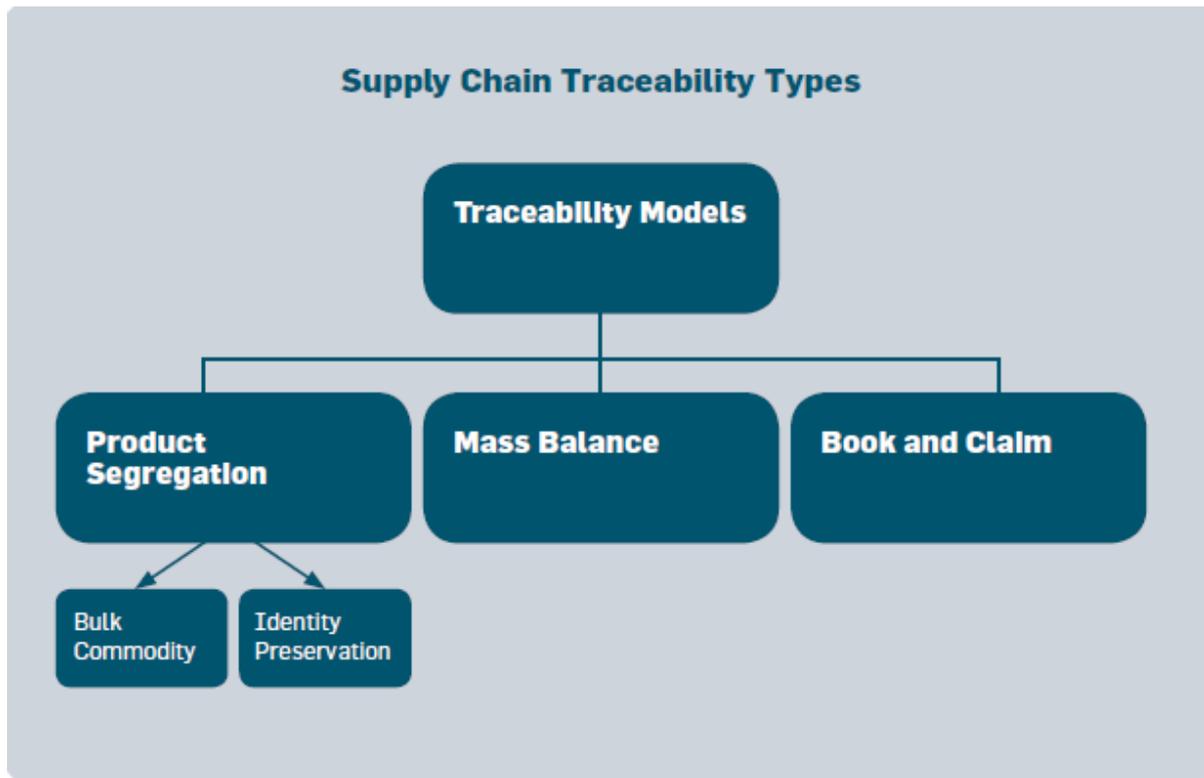
## 2.3 Traceability Systems

UN Global Compact (2014) notes that there are 3 main traceability models. These are:

- **Product Segregation** - Certified materials and products are physically separated from non-certified materials and products at each level along the value chain. E.g. in the banana value chain. Bulk commodity separates certified from non-certified products; mixing of certified products is allowed. Identity preservation doesn't allow mixing of certified material throughout the value chain.
- **Mass Balance** - certified and non-certified materials can be mixed. However, the exact volume of certified material entering the value chain must be controlled and an equivalent volume of the certified product leaving the value chain can be sold as certified. E.g. in the cocoa value chain.
- **Book and claim** - does not seek to have traceability at each process in the supply chain. Instead, this model relies on the linkages between the volumes of the certified material produced at the beginning of the food supply chain and the amount of certified product bought at the end of the value chain.

These models are summarized in Figure 8.

Figure 8: Traceability Models



Source: UN Global Compact (2014)

Salient features in all these traceability models are their focus on end – to – end functionality, linking all the different stakeholders in the food supply chain. There is also the presupposition of uniformity in standards for products in the traceability system. Traceability is also forward (from supplier to end buyer) and backward (from end buyer to supplier). This then requires effective inter-connectedness of the people, processes, and information flows in a traceability system.

## 2.4 Transformative Technologies in Traceability Systems

This section highlights some of the transformative technologies that are in use in traceability systems in food supply chains.

### 2.4.1 Blockchain

Sharma et al (2022) define Blockchain as a distributed-ledger technology that uses smart contracts to share multi-party transactions with the member organizations of a business network. Trust is built in these networks by providing cryptographic proof over a set of facts: the information that one participant sees is the same as what another participant sees.

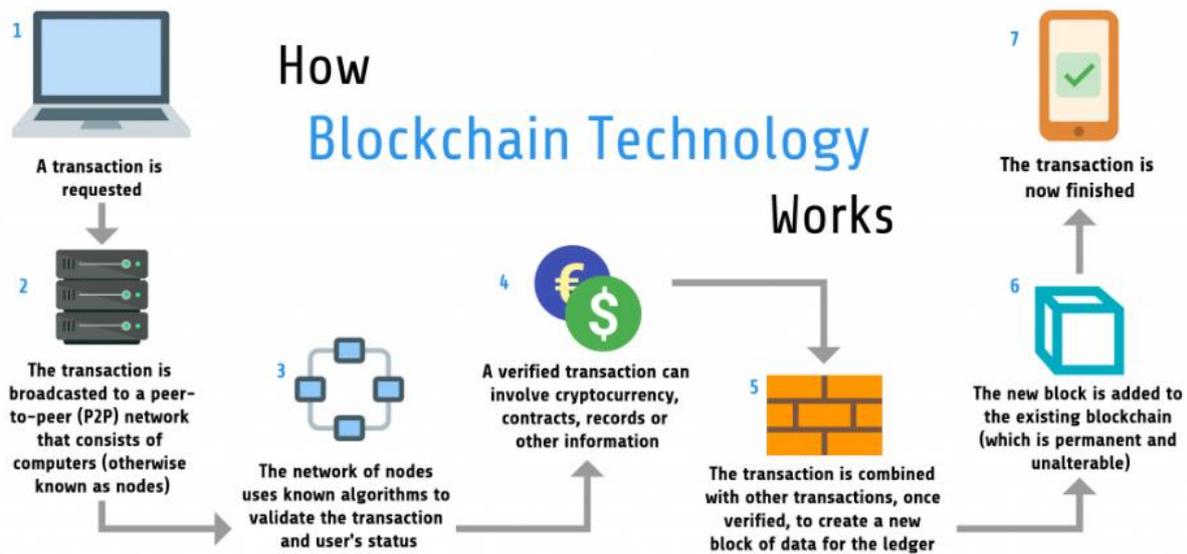
IBM (2022a), states that Blockchain helps supply chain stakeholders share trusted data through permissioned solutions. This allows for businesses and customers be confident of brand authenticity. It also allows for supply chain stakeholders to demand responsible sourcing and better visibility to minimize disputes. Blockchain for supply chain solutions help supply chain leaders use data to manage the disruptions of today and build resiliency for the future.

Demestichas et al (2020) note that Blockchain is an immutable digital ledger- tampering with or corrupting the data of a specific block, thus changing the hash of this block will result in a cryptographic link disruption, due to the usage of different hash(es) between the linked blocks of the

chain. Because of the change in a block in the chain, all the blocks after that will no longer be valid and will no longer be connected to the chain. Data entered into the blockchain cannot be altered, as all the entries following the tampered block of the chain need to be altered as well. Because of this fundamental structure, it is impossible to change a single block in the chain, especially as more components are added.

Figure 9 summarizes how Blockchain works.

Figure 9:How Blockchain Technology Flows



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

IBM (2022b) notes that Blockchain can be utilized to ensure supply chain transparency and increase food safety and freshness. The IBM Food Trust is linking various stakeholders in the food industry, and their collaboration is improving confidence in the world’s food supply.

#### 2.4.2 Internet of Things - IoT

Oracle (2022) defines The Internet of Things (IoT) as the network of physical objects— things—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These devices can be ordinary household objects to sophisticated industrial gadgets. With more than 7 billion connected IoT devices today, experts are expecting this number to grow to 10 billion by 2020 and 22 billion by 2025.

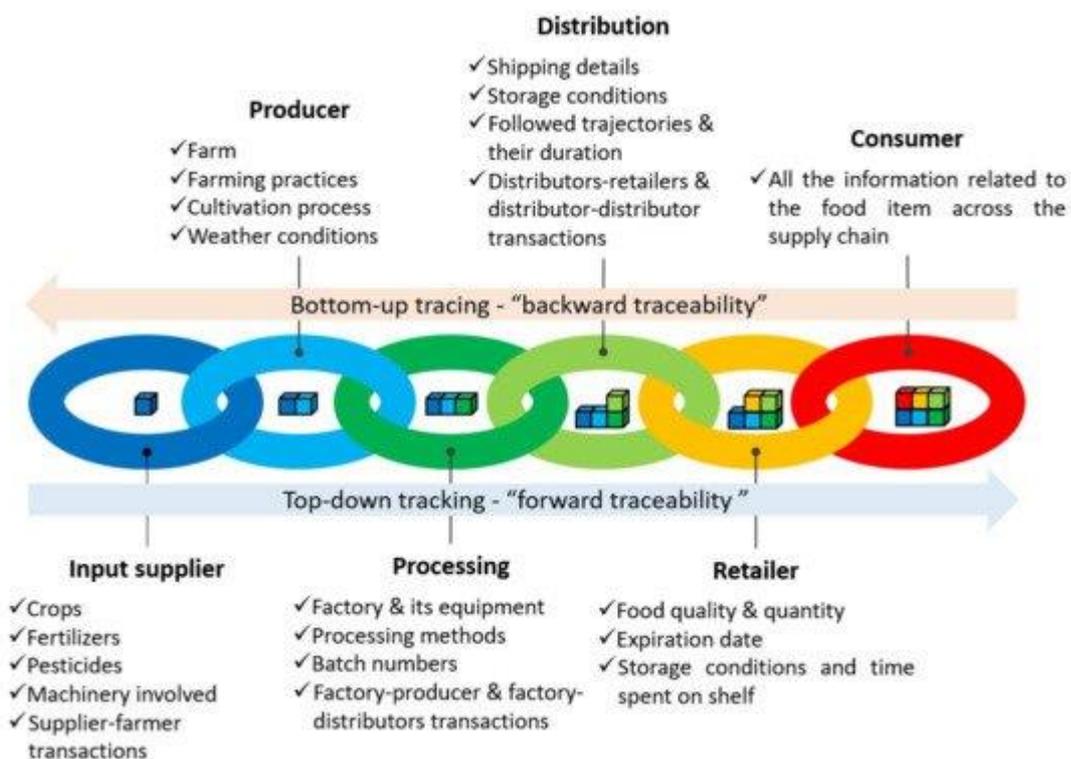
By means of low-cost computing, the cloud, big data, analytics, and mobile technologies, physical things can share and collect data with minimal human intervention. Digital systems can record, monitor, and adjust each interaction between connected things. The physical world meets the digital world—and they cooperate. (Oracle 2022).

IoT has application in various industries including healthcare, agriculture, travel and logistics and supply chains. Nagarajan (2022) notes that IoT helps to integrate the supply chain and improve efficiency in different processes in supply chains. He further notes that IoT supply chain

management tools mine useful data within and beyond the enterprise to maximize asset utilization as well as customer value. An IoT-enabled supply chain offers contextual intelligence. This is in areas like asset control, statutory compliance, reconciliation of products and assets and ensuring the integrity of cold chains. (Infosys, 2022)

On the website IoT for All (2019) it is noted that IoT can enhance food quality by regulating temperature, lighting, air conditioning and watering. It can also be used to examine foods on the production line to ensure compliance with food standards. Oracle (2022) further notes that the food and beverage, flower, and pharmaceutical industries often carry temperature-sensitive inventory that would benefit from IoT monitoring applications that send alerts when fluctuate to levels that threatens the product. Figure 10 illustrates the different types of information monitored, using IoT at various levels in the supply chain.

Figure 10: IoT monitoring in the fresh produce food chain



Source: Tagarakis et al (2021)

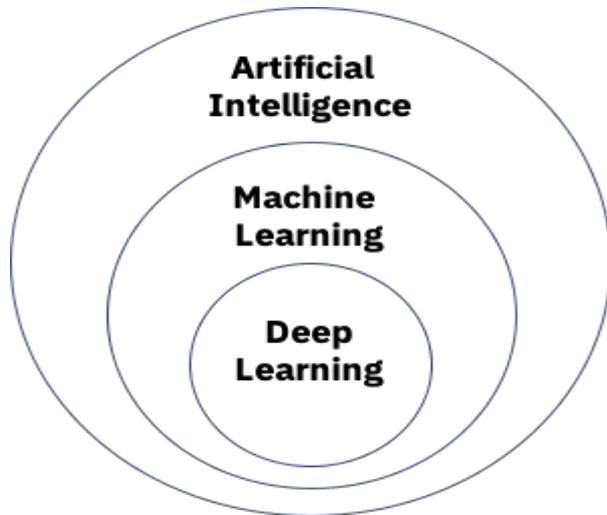
### 2.4.3 Artificial Intelligence - AI

IBM (2022c) defines artificial intelligence (AI) as a combination of computer science and robust datasets, to enable problem-solving. It also encompasses sub-sets of machine learning and deep learning, which are frequently mentioned in conjunction with artificial intelligence. These disciplines are comprised of AI algorithms which seek to create expert systems which make predictions or classifications based on input data.

Sebastian (2018) notes that Artificial Intelligence (AI) is improving food safety initiatives by effective monitoring of processes in the supply chain, enhanced traceability with precision and automation in sanitation processes in the food supply chain. However, AI is still a growing technology with more advances being made on how it can be leveraged in various processes in the food supply chains.

Deep learning and machine learning are sub-sets of artificial intelligence, and deep learning is actually a sub-set of machine learning. (IBM,2022). This is illustrated in Figure 11.

Figure 11: AI Sub-sets

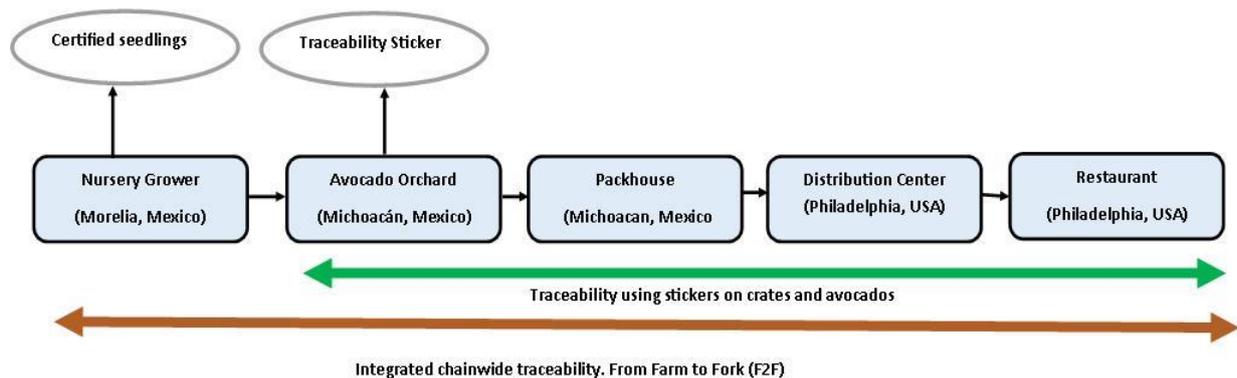


Source: IBM (2022)

## 2.5 Avocado Traceability - Case Study of Mexico

Aguirre and Gomez (2020) note that the State of Michoacan, Western Mexico accounts for 89.4% of all avocado exports from the country. This makes this region a good case study for a success story in avocado tracing and traceability. An overview of the traceability was given by the study, followed by a step-by-step traceability journey of an avocado fruit from this region to a consumer in the USA. Figure 12 illustrates the traceability steps for an avocado fruit from Michoacan, Mexico to Philadelphia, USA. The movement from the avocado orchard to the restaurant is completed in 4-5 days.

Figure 12: Traceability in the Mexico Avocado Value Chain



Source: Author's compilation adapted from the Documentary, Avocadoland

The detailed traceability measures at each of these stages is detailed in Table 1.

Table 1: Traceability in the Mexico Avocado Value Chain

STEP	TRACEABILITY MEASURES
Nursery Grower	<p>Output: Certified avocado seedlings</p> <ul style="list-style-type: none"> <li>• Specialized growers growing 4 types of blooms year round (loca, aventajada, normal, marzena)</li> <li>• Use natural irrigation and composting manure</li> <li>• Soil is disinfected with ash before being potted for planting seedlings.</li> </ul>
Avocado Orchard	<p>Output: Certified and traceable avocados harvested</p> <ul style="list-style-type: none"> <li>• Integrate very smallholders (the smallest has 5 avocado trees)</li> <li>• Farmers are registered under very strict guidelines in 18 Juntas Locales (Municipalities)</li> <li>• Municipalities inspect orchards and confirm avocado dry matter before harvesting</li> <li>• Strict phytosanitary procedures adhered to before harvesting e.g. disinfecting hands and tools. Use of special clippers and bags for harvesting to avoid damaging the avocados.</li> <li>• Experienced pickers</li> <li>• Traceability sticker is placed on each crate with details of municipality, orchard number and date of harvest</li> <li>• Transport immediately to packhouse in cooling trucks with sensors to monitor temperature and sealed with nets to avoid bugs.</li> <li>• Trucks are locked and sealed to avoid opening during transportation.</li> </ul>
Packhouse	<p>Output: Certified and traceable avocados</p> <ul style="list-style-type: none"> <li>• 3rd party inspection of trucks before opening—for the seal and stickers on crates</li> <li>• Sampling and checking for foreign matter</li> <li>• Dry matter inspection</li> <li>• Automated feeder for cleaning, brushing and applying stickers.</li> <li>• Visual grading and packing by different sizes</li> <li>• Storage in monitored cool rooms for 1-2 days.</li> </ul>
Distribution Center	<p>Output: Certified and traceable avocados</p> <ul style="list-style-type: none"> <li>• Offloading from trucks directly to cool rooms</li> <li>• Controlled ripening process according to client specifications—68F for ripening and 38F to stop ripening process.</li> <li>• Sorting according to size, uniformity in color and no defects</li> </ul>
Restaurant	<p>Output: Certified and traceable avocado</p> <ul style="list-style-type: none"> <li>• Receipt of avocados in boxes, with traceability stickers that allow for tracing back to the grower.</li> </ul>

Source: Author's compilation adapted from the Documentary, *Avocadoland*

## 2.6 Conceptual Framework

Varpio et al (2020) define a conceptual framework as the justification for conducting a specific study. The conceptual framework describes the state of what is known, identifies gaps in our understanding of an issue and outlines the methodological foundations of the research project.

The objective of this study was to assess the readiness in adopting integrated chain- wide ICT based traceability solutions in the local and export oriented avocado value chain in Nandi County, Kenya. Gupta (2016) confirms that the incorporation of ICT driven solutions in the prevailing Food Supply Chain (FSC), can contribute towards ensuring an integrated 'farm to fork' model of food delivery.

3 frameworks were analyzed and combined to develop the conceptual framework for this study. These are:

1. The Network Readiness Index (NRI).
2. Value Chain Analysis
3. Triple Layered Business Model Canvas (TLBMC)

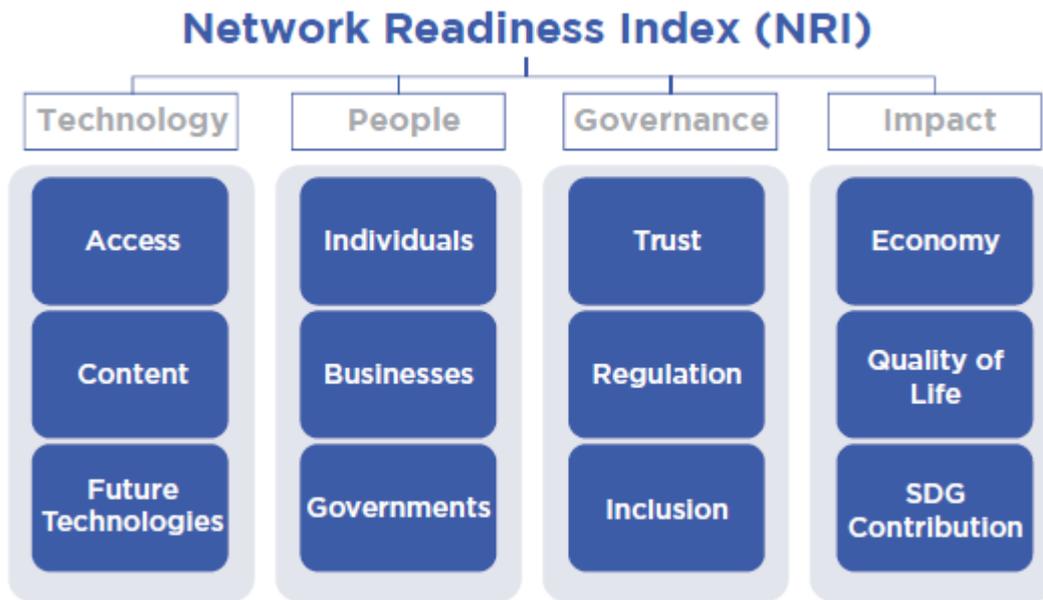
### 2.6.1 Network Readiness Index

According to Porlutans Institute (2021) the Network Readiness Index (NRI) consists of 4 core pillars that make up the fundamental dimensions of network readiness. These include:

1. Technology – level of technology in a country
2. Governance – network economy, regulation, and digital inclusion, chain governance (formal or informal) and contracts.
3. People – access to technology, knowledge, and skills
4. Impact – improve short- and long-term growth and wellbeing in the organization, society, and the economy.

The Network Readiness Index (NRI) provides a methodological framework that identifies the factors enabling economies to fully benefit from information and communication technology (ICT) advances. Because of this, many countries use the NRI to design their digital strategies (Porlutans Institute, 2021). The NRI is a tool that allows countries and organizations to gauge their readiness in adopting ICT tools. The 4 pillars are represented in Figure 13.

Figure 13: Network Readiness Index



Source: Network Readiness Index Database, Porlutans Institute (2021)

Figure 14 illustrates the NRI top 3 countries by region.

Figure 14: NRI Top 3 Countries by region

Africa	Arab States	Asia & Pacific	CIS	Europe	The Americas
1. South Africa (70)	1. United Arab Emirates (34)	1. Singapore (7)	1. Russian Federation (43)	1. Netherlands (1)	1. United States (4)
2. Mauritius (71)	2. Saudi Arabia (40)	2. Korea, Rep. (12)	2. Armenia (60)	2. Sweden (2)	2. Canada (11)
3. Kenya (84)	3. Qatar (42)	3. Australia (13)	3. Kazakhstan (61)	3. Denmark (3)	3. Chile (44)

Source: Network Readiness Index Database, Porlutans Institute (2021)

Kenya is ranked 3 in Africa and 84<sup>th</sup> overall. The Netherlands, the destination for the majority of Kenyan avocados is ranked 1<sup>st</sup> in Europe and 1<sup>st</sup> overall. This presents a comparative opportunity between these two countries. The Porlutans Institute (2021) notes that network readiness requires holistic approaches. It is observed that the leading countries in network readiness have strong competencies across all the pillar dimensions of the NRI. This therefore implies the need to do a holistic evaluation of the avocado value chain in Nandi County.

### 2.6.2 Value Chain Analysis

The value chain mapping highlights the connection among the actors in the chain. This allows for an understanding of the products flow (Lundy et al., 2014). According to Verschuur (2021) the value chain analysis (VCA) is composed of four parts: stakeholder analysis, context analysis, qualitative and quantitative analysis. The first part, the stakeholder analysis, involves the highlighting of the actors and supporters and their roles in the chain. The context is the analysis of factors influencing chain performance. The qualitative allows the highlighting of chain relations, while the quantitative analysis covers the actors' value shares and information like prices (Verschuur, 2021).

For this study, 3 facets (context analysis, stakeholder analysis and qualitative analysis) were considered to allow for an analysis into these factors and how they relate to the NRI discussed. All these are core elements in examining the network readiness of an organization.

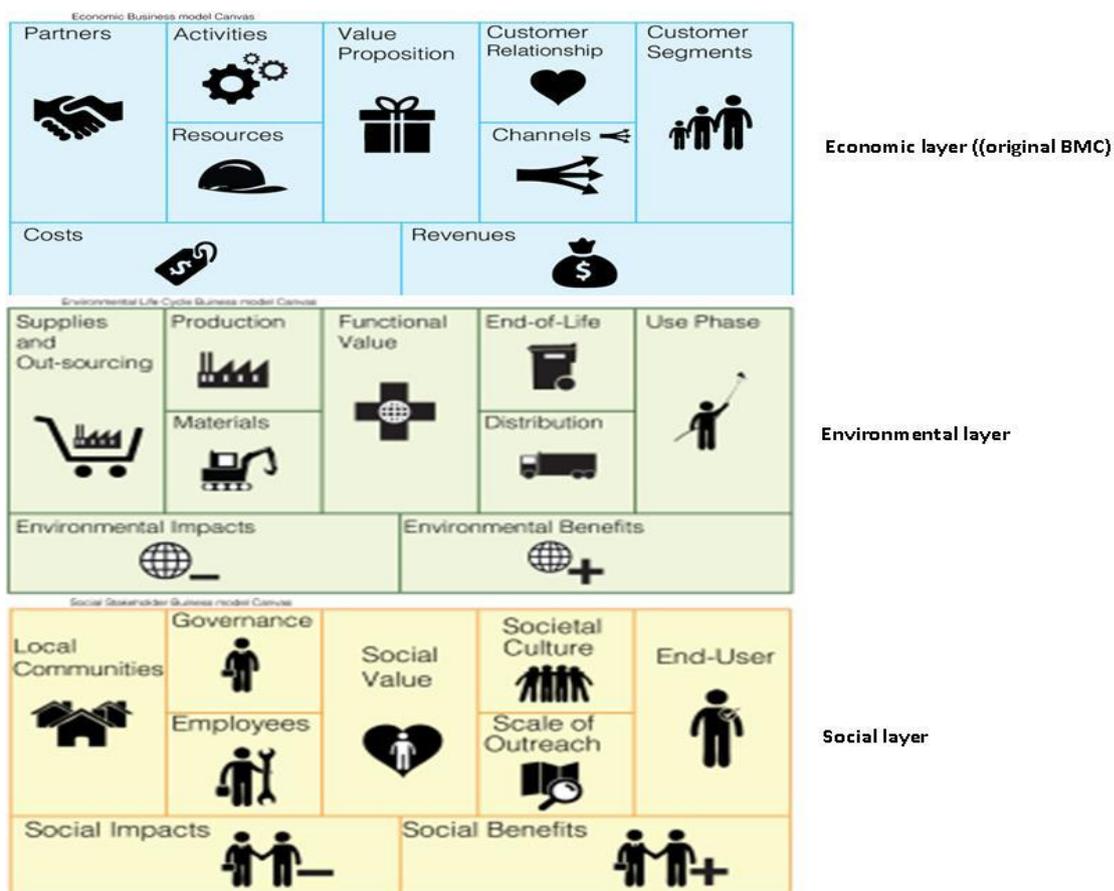
### 2.6.3 Triple Layered Business Model Canvas (TLBMC)

Strategyzer (2021) defines the BMC as nine building blocks that shows the logic on how a company intends to deliver value to its customers and generate revenues. The BMC allows for a snapshot analysis of these nine business blocks of a company or organization. However since this study adopted a sustainability aspect to it, the Triple Layered Business Model was adopted for the conceptual framework as it will allowed for the 3Ps of sustainability – people, planet, profits to be explored.

Joyce and Paquin (2016) also note that the triple layered business model canvas adds environmental and social components to the original business model canvas that focuses on the economic aspect of organizations. The TLBMC, thus allows for organizational analysis through sustainability lenses.

The TLBMC was specifically used to analyze the avocado value chain in Nandi, and specifically, the Nandi Avocado Cooperative Society and the avocado value chain in Mexico. This allowed for a deeper analysis at organizational level. The Triple Layered Business Model Canvas (TLBMC) is represented in Figure 15.

Figure 15: Triple Layered Business Model Canvas

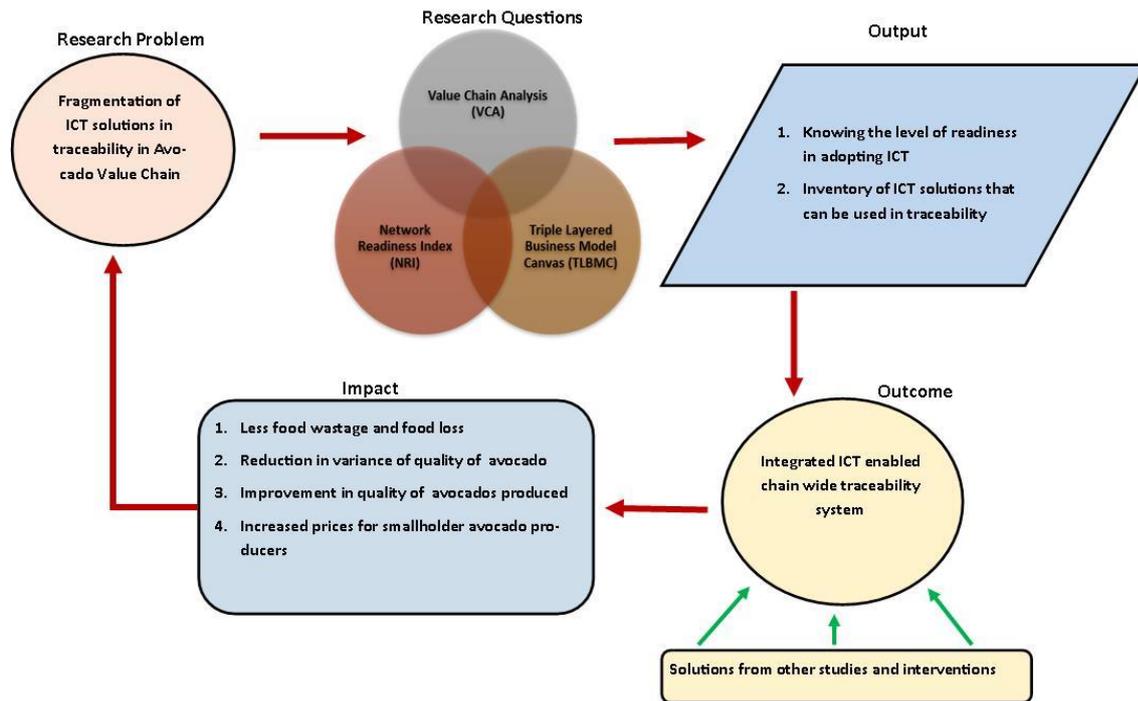


Source: Joyce and Paquin (2016)

## 2.7 Conceptual Framework for study

The conceptual framework for this study was therefore a combination of the Network Readiness Index, Value Chain Analysis, and the Triple Layered Business Model Canvas. This is illustrated in Figure 16. These 3 frameworks allowed for the research questions to be examined and answered. The outcome of the study was the contribution towards integrated ICT enabled chain wide traceability in the avocado value chain. Other studies and interventions also contribute to this but are beyond the scope and boundaries of this study.

Figure 16: Conceptual Framework for study



Source: Author's own composition

## 2.8 Operationalization

From the conceptual framework developed, the operationalization is represented in Table 2.

O'Leary (2021) defines operationalization as turning abstract concepts into measurable variables. This allowed for the collection of data to answer the different research questions for this study.

Table 2: Operationalization of concepts

Key Concept	Dimensions	Indicators
ICT in integrated traceability systems	Context Analysis	PESTEC Analysis
		SWOT Analysis
	Stakeholder Analysis	Actors
		Supporters
		Influencers
	Qualitative Analysis	Chain Relations
		Market Institutions
		Information Flow
	Business Model	Building blocks of the Triple Layered Business Model Canvas
	Technology	Access
		Content
Future Technologies		

Source: Author's compilation

# CHAPTER THREE



## CHAPTER 3 RESEARCH METHODOLOGY

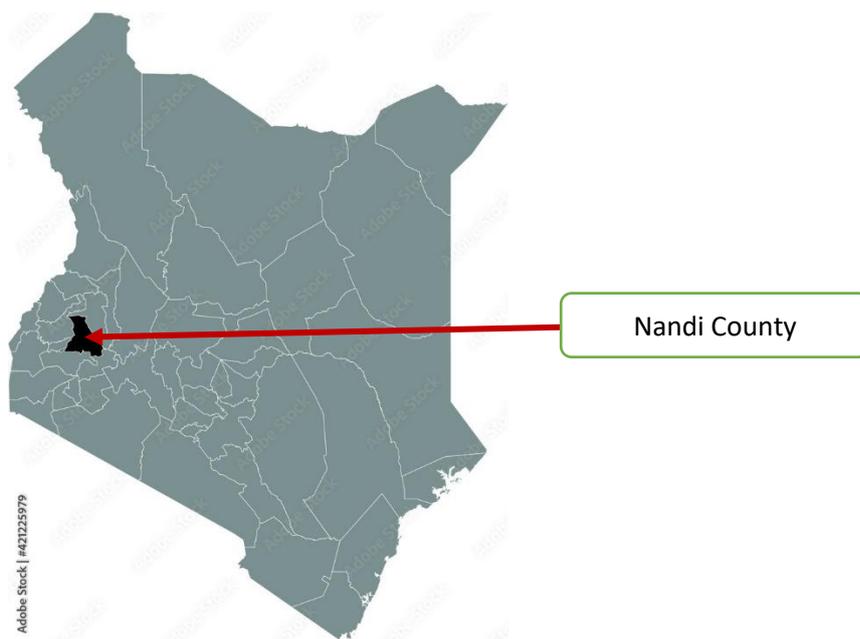
It was important to understand the present avocado value chain in Nandi County in terms of stakeholders, chain governance, market institutions and information flows. This allowed for an assessment of what will be needed to develop an integrated traceability system. The other concepts examined are the different aspects of ICT and their potential use in developing integrated chain wide traceability systems in the avocado value chain that is inclusive of both the domestic and export market.

### 3.1 Study Area

The study was conducted in Nandi County. Nandi County is located in the North Rift of Kenya, bordering Kericho and Kisumu Counties to the South; Vihiga and Kakamega Counties to the West; and Uasin Gishu County to the East and North. It covers an area of 2,884km<sup>2</sup> at altitude of 2,047m. (Nandi County, 2022) Nandi County (2022) also notes that the population is 885,711 as at the 2019 population census. This includes 441,259 males, 444,430 female and 22 intersex persons.

Nandi County (2022) notes that the headquarters are in Kapsabet Town. The constituencies of the County are: Tinderet, Nandi Hills, Aldai, Mosop, Chesumei and Emgwen. Figure 17 shows the location of Nandi County.

Figure 17: Location of Nandi County



Source: Adobe Stock (2022)

### 3.2 Research Approach

The social constructionist framework was used in carrying out this research. Laws et al (2013) state that social constructionist approaches maintain that there is no one right answer to an issue. They further note that the interviewees are actively engaged in discovering their world as is their researcher. O’Leary (2021) confirm that qualitative research is usually tied to a set of assumptions related to relativism, social constructionism, and subjectivism. Laws et al (2013) further note that the key to embracing this research approach, is to make conscious decisions, in light of research

purpose. This implies the centrality of objectivity in collecting and analyzing data from qualitative research.

### 3.3 Research Strategy

Qualitative research methods were used to collect data for this study.

Aspers and Corte (2019) note that qualitative includes case study, personal experience, introspective, life story, interview, observational, historical, interactional, and visual. Asper and Corte (2021) further define qualitative research as an iterative process where continuous examination of an issue allows for a deeper understanding into that issue.. Denny and Wekesser (2018) assert that qualitative research is not quantifiable, generalizable, or a poor substitute for quantitative research. They conclude by noting that rigor, skill, and expertise is required to collect and analyze qualitative data.

The qualitative research approach was used because it aided in finding out in-depth information, about the readiness for adopting integrated ICT based traceability solutions in the avocado chain in Nandi County. Hammerberg et al (2016) confirm that qualitative research is used in investigating beliefs, attitudes, and concepts of normative behavior. They also note that the topic under research is usually focused, and key informants are used to understand a particular situation. Documents and texts e.g. reports and websites were also included to learn more about specific knowledge.

### 3.4 Data Collection Methods

Various methods were used to collect data for this qualitative study. These included semi-structured interviews and a case study of the Mexico avocado value chain. Secondary data was used to define the theoretical and conceptual frameworks for this study. The use of different ways allowed for triangulation and increased the validity and reliability of data collected. Laws et al (2013) assert that the methods used to collect data have an effect of the quality information collected.

#### 3.4.1 Desk Review

Secondary data on use of ICT in traceability systems in value chains was reviewed. Academic search engines e.g. Google Scholar, Greeni and ResearchGate were used to find relevant information on this study. Boolean operators AND and OR in combination with key search phrases like “avocado,” “ICT”, “traceability”, “agriculture”, “food chains”, “digitalization” was used to search for relevant literature. Secondary data was used to develop the theoretical and conceptual frameworks for this study and to complement the discussion of the results from the study.

#### 3.4.2 Case Studies

Rebolj (2013) defines a case study as a detailed explanation of a case and its analysis, i.e., the characterization of the case and the events, as well as a description of the discovery process of these features that is the process of research itself. O’Leary (2021) observes that using case studies require depth. The researcher must dig into details and context and understand the rich experiences of the phenomena being explored. A case study on success stories on implementation of traceability systems in horticulture value chains was analyzed, and lessons drawn that can be applied to this study. The case study explored was the Association of Avocado Exporting Producers and Packers of Mexico (APEAM). Mexico is the world’s largest exporter of avocado and APEAM represents 74 packing houses, 30,000 growers in 42,000 orchards. (Avocado Institute, 2022). This tracked an avocado journey from production in Michoacan in Mexico to Philadelphia in the USA. This was by viewing and analyzing a documentary capturing this process.

### 3.4.3 Semi structured interviews

Semi-structured interviews were carried out with experts, on ICT use in agriculture chains and stakeholders in the avocado value chain to find out the value chain structure and governance and assess the readiness in adopting integrated ICT solutions in traceability in the avocado value chains. Other stakeholders not directly involved in the present value chain in Nandi County were also interviewed, for the relevant information they had on managing traceability aspects in the avocado chains. These included stakeholders like an international logistics provider and an avocado importer in the Netherlands who presently does not have a presence in Kenya.

O'Leary (2021) defines a semi-structured interview as being flexible. Interviewers start with a pre-determined questioning plan but will be flexible to pursue interesting tangents to the responses given. As such this allows for rich information to be collected, if the right questions are posed, followed with appropriate probing questions.

Monke (2022) describes the expert interview as an informative and investigative form of interview in order to learn about specific knowledge. The respondent is regarded as an authority in their field. The use of ICT experts was justified in this study because specific knowledge on the application of ICT in traceability in the avocado value chain requires insights from individuals who are well versed with knowledge in this field.

## 3.5 Target Population

The target population was experts on ICT and traceability and stakeholders in the avocado value chain in Nandi County. Though not specific to avocado value chains, knowledge on traceability in agriculture chains as a whole can be used to tailor solutions for this avocado value chain study.

## 3.6 Sampling

Purposive sampling was used to identify the sample of experts and stakeholders to be interviewed. According to Business Research Methodology (2022), purposive sampling is a non-probability sampling method when participants selected for the sample are chosen using the discretion of the researcher. Sound judgement is required on the part of the researcher to obtain a reflective sample. It is further observed that this method is effective when a limited number of people can serve as primary data sources. In this case, expert knowledge was needed on ICT use in traceability and participation in the avocado value chain in Nandi County and/or FORQLAB project were the factors considered.

Snowballing was used to identify the experts and stakeholders to be included in the sample. O'Leary (2021) describes snowballing as building a sample through a series of referrals. E.g., asking initial interviewees to nominate other potential interviewees who then nominate further interviewees. O'Leary (2021) further notes that since snowballing does not guarantee representativeness, a population profile can be created from literature and then assessing sample representativeness by comparing samples with the profile.

For this study, the researcher's industry contacts and networks were used to develop the initial participants in the study. A total of 23 interviewees were included. These included stakeholders in Kenya and business partners in the FORQLAB project in the Netherlands and allowed for a full spectrum on insights from farm to fork. Interview sessions were conducted face to face, and some were carried out on Microsoft Teams and Zoom to accommodate interviewees schedules. Some interviews were video recorded while some were not as interviewees declined any form of

recording. The researcher then had to take notes during the interview. For the interviews conducted face to face, the researcher used an assistant to assist in taking pictures and videos of the interviews.

For 2 of the ICT experts, multiple interviews were conducted with them to follow up on technical terminologies used during interviews. This allowed for a more in depth understanding of the information provided. 1 of the ICT experts preferred having the questions mailed to her for responses, as she was juggling multiple projects and could not find an appropriate time for an interview. This proved to be an excellent strategy as she was able to, in a course of a week, provide incredibly detailed information on questions asked. The researcher then made follow up on the responses to ensure clarity on information provided. Information saturation was reached when there was no new information being presented by interviewees.

### 3.7 Data Analysis

Analysis of data collected from the qualitative research was done in Atlas.ti using the core process outlined by Laws et al (2013) that draws out key themes that summarize the important categories in the data and their relationship with each other. Interview recordings were transcribed and using the steps highlighted in the core process, categorized into various themes that addressed the various indicators in the operationalization of this study and answered the research questions. All transcriptions except 2 were manually done by the researcher. The last interview done on Microsoft Teams allowed both for a recording and transcription of the interview. The transcript was then edited to ensure coherency in the information provided. 1 interview with an ICT expert was conducted by emailing the questions, and having written responses emailed back to the researcher.

Laws et al (2013) further highlight the following steps in the core process. Table 3 represents the steps in the core process.

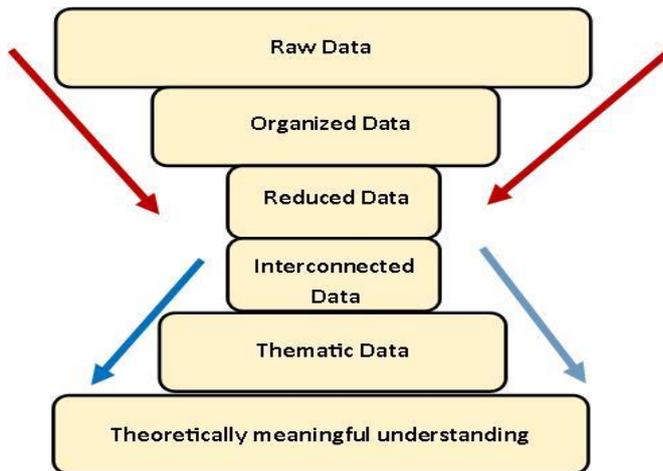
Table 3: The Core Process for qualitative analysis

Steps in the Core Process	
1	Familiarize yourself with data by reading and re-reading notes, interview schedules and transcripts
2	Make a preliminary list of themes and categories in the data
3	Review data again making notes, theme wise
4	Compare categories before and after 2nd review and make further changes as problems emerge
5	Set categories in a clear format e.g. charts so they can be linked to notes
6	Review data again noting all material relating to each category under its heading
7	Examine each category to make sense of data collected.

Source: Laws et al (2013)

O’Leary (2021) illustrates this process in Figure 18.

Figure 18: Qualitative data analysis: drilling in and abstracting out



Source: O'Leary (2021)

Some of the recurring themes from the analysis included:

- Partnerships and collaboration
- Training
- Regulation and policy
- Certification and Standards
- Transparency
- Block Chain
- IoT Sensor Technology
- Food safety
- Data
- Simple to use

### 3.7.1 Validating qualitative data

Laws et al (2013) provide the following check list to ensure the validity of findings from qualitative data.

- Themes should mirror research questions and data
- The research topic should be approached objectively
- Explore different explanations
- Present the data in perspective
- Ensure triangulation of findings
- Check conclusions back with interviewees
- Use existing appropriate research findings to justify your data
- The research and analysis processes need to be made explicit.

## 3.8 Ethical Considerations

O' Leary (2021) defines ethics as professional code of practice to protect the people being researched from processes that are not ethical, and also protect the researcher from legal liabilities.

Some ethical considerations for this study included:

1. Ensuring the interviewees have informed consent before participation in the interviews. This included informing the interviewees on the purpose of the interviews with findings being solely used for the purposes of the study.
2. Requesting for permission to record interviews and recording the interview in other ways e.g. notetaking if interviewees decline to be recorded.
3. Reiterating the right to privacy for the interviewees. However, the researcher asked the ICT experts and FORQLAB business partners to waive this, so that information could explicitly be used both for the thesis project and FORQLAB project. One ICT expert declined this waiver and was therefore not included in the study.
4. Collaborating with a research partner during fieldwork.

# CHAPTER FOUR



# CHAPTER 4 RESULTS

This chapter reports the findings from the study from the various interviews conducted. This qualitative study entailed conducting in-depth interviews with different stakeholders in the avocado value chain in Nandi County and with different business partners in the FORQLAB project. The results are presented in the sequencing order of the research sub questions as this allows for logical examination and presentation of the results.

All the research sub questions were explored in the context of the research objective – assessing the readiness in adopting an integrated ICT enabled chainwide traceability system.

Some of the tools used to present the results include value chain map, PESTEC analysis, SWOT analysis and Triple Layered Business Model Canvas (TLBMC)

## 4.1 Value chain stakeholders and their role in the avocado value chain

**Sub question 1: What are the responsibilities, interests and power of the various actors, supporters, and influencers in the avocado value chain in Nandi County?**

### 4.1.1 Value chain actors and their role in the value chain

Value chain actors are the stakeholders that directly involved in the chain and who own the product, commodity, or service. There are various actors in the avocado value chain in Nandi County, all playing different roles and holding various interests concerning traceability in the value chain. Input suppliers provide the seedlings and other inputs required for avocado cultivation e.g. fertilizers and chemicals used in maintaining the avocado trees. Farmers produce the avocados and sell them to the exporters through the Nandi Avocado Cooperative Society. Wholesalers also buy from the farms during harvest the fruits not sold to the exporters. Wholesalers further sell to retailers in smaller quantities. The exporters on the other hand either process the avocados for export or sell them to oil processors for the avocados that do not meet export requirements.

The various actors, their roles and responsibilities are discussed as follows:

#### **Input suppliers:**

Seedlings are purchased either from certified farmers groups or uncertified seedling providers, though farmers are discouraged from buying from them as they will not produce avocados that will meet market requirements. Figure 19 illustrates seedlings at a nursery in Nandi County.

*Figure 19: Avocado seedlings in nursery*



*Source: Simon Tuwei's Farm, Nandi County*

## **Producers/Farmers:**

Farmers are venturing into avocado farming as a means of diversification from maize farming that is being affected by climate change. Previously, traditional varieties of avocados were cultivated but there is now the adoption of Hass and Fuerte varieties that are demanded by the market. The farmers belong to Nandi Avocado Cooperative and are about 950 in number. 360 of these farmers have already planted avocado trees. Hass, Fuerte and the traditional varieties are grown by farmers.

The farmers are smallholders with average acreage of 1 acre (0.4 hectares) of land under avocado cultivation. The maturity of the avocado trees is 3-4 years, and the cultivation is rain fed. Some of the challenges they face include hailstorms, pests and diseases and meeting production of avocados meeting market requirements.

Avocado is considered a good crop for retirees because they have access to land. Young people have no land and want quick money and therefore do not want to wait the 3-4 years before the crop matures for harvest.

The farmers get basic training from Sunripe company, the main exporting company that purchases the avocados from farmers. They get training on avocado sizes, but not on the other quality requirements like acceptable residue levels, dry matter content, testing for harvest readiness and this leads to high rejection rates, at the cost of the farmer. Farmers expressed the need to have comprehensive training on the market requirements, so they are able to produce avocados that meet these standards. They also noted that training is required at all levels of the production process and should include processes like land preparation e.g. digging planting holes for avocado trees, using compost properly to ensure proper root development that then affects the quality of avocado produced.

Farmers also expressed the desire to have strengthened partnerships with different stakeholders in the value chain, and especially with the exporters at production level and with importers for market linkages.

Traceability ends after the avocados are harvested by the exporter and transported to the packing house. At the packing house, the exporter then determines what fruits are meeting export requirements and those not meeting these requirements are rejected, at the farmers cost.

To this end, farmers expressed the following:

1. The need to have a cold room or cold storage at cooperative level so that avocados are cooled immediately after harvest.
2. Partnerships with certified seedling suppliers to ensure standard and certified quality of avocados are produced by all cooperative members.
3. Hire knowledgeable staff at the cooperative to ensure availability of extension services to all farmers.
4. Work through the cooperative to ensure farmers have the certification needed to access export markets. They noted that by working through the cooperative, they will be able to have enough volumes to profitably access the export markets, and also adhere to standards. With traceability, they will be able to know if their fruits are meeting standards and make corrective actions as required. E.g. if a few farmers are liable for avocados not meeting

standards, they will be easily identified. They noted that this will help with reputation control and avoid high rates of rejection of the fruits.

Figure 20 shows a smallholder avocado farm in Nandi County, Kenya.

*Figure 20: Avocado farm in Nandi County*



*Source: Pius Choge's Farm, Nandi County, Kenya*

#### **Exporters:**

There are 2 main exporters that buy avocados from the smallholder farmers in Nandi County:

1. Sunripe Kenya
2. Keitt Exporters Ltd

These exporters harvest the avocados from the farms and transport them to their packhouses for processing. The farmers do not know if their fruits are meeting the required quality until the processor has graded their avocados. Sunripe Kenya provides training to the farmers in terms of the avocado sizes required. They do not provide additional training on other quality attributes like MRLs, dry matter content or proper harvesting techniques. Due to this, there is up to 60% rejection rates of avocados transported to the packhouse, losses that are absorbed by the farmers. Keitt Exporters are a new buyer in Nandi County, purchasing both Hass and Fuerte varieties.

#### **Processors:**

Processors buy avocados not purchased by the exporters and use them for oil processing, making soaps and cosmetics. The processing companies are based in Nairobi not Nandi County.

#### **Wholesalers:**

Wholesalers, like the processors, also purchase avocados not collected by the exporters. These wholesalers then sell in smaller quantities to retailers in Nandi County or to neighboring counties like Uasin Gishu and Vihiga. Wholesalers also buy avocados from other towns like Kisii and Webuye. This is to ensure they always have a constant supply of avocados to sell.

**Retailers:**

Retailers sell the avocados directly to the end consumers. For the study, different types of retailers were interviewed including those with permanent market stalls selling fruits and vegetables, those with small grocery shops and selling fruits and vegetables as extensions of their shops and those hawking avocados in strategic places within the town e.g. at bus stages/stops. Retailers also buy from transporters who buy and sell avocados from other towns like Kisii and Webuye.

**Transporters:**

Transporters ferry avocados (and other fruits and vegetables), to and from Nandi County and other town in Kenya e.g. Kisii and Webuye. The study did not find any specialized avocado transporters within the county or any having specialized cooling trucks. The avocados are transported in lorries, including other produce. Records are only kept for quantities carried and for customer orders.

**Nandi Avocado Cooperative Society:**

The cooperative is the umbrella body under which the avocado trading and marketing in Nandi County occurs. The membership is about 950, with continued growth as more members join avocado cultivation. Women comprise about 360 members of the cooperative. The age range for the members is 25-100 years. There is however a paucity of young members, as they don't own land. It was however noted that there are 5 young women, studying abroad, who are members of the cooperative, as they seek to invest back home.

The main functions of the cooperative include supplying seeds to farmers, training on GAP and marketing of the avocados. The cooperative Secretary noted that even with some partnerships with organizations like World Bank (under the NARIG project), Equity Bank (through the Mastercard Foundation), JICA, Safaricom, and the Nandi County Government, efforts to ensuring traceability have not been harmonized because each organization only focusses on their own projects and programs.

Some challenges faced by the members of the cooperative include pests and diseases, hailstorms and production of un-certified avocados that do not meet market standards.

The need for capacity building for farmers was noted, ideally from ward level to ensure most farmers are reached. The capacity building would be to scale up on training on GAP and market requirements. Knowledge on farmers experiences with tea, a commodity most of them plant and are certified in could also be leveraged upon.

The cooperative also expressed the desire to partner with exporters and importers in provision of information on the production processes and gadgets for proper harvesting of the avocados. This is to ensure that from inception, there is monitoring of the avocados and ensuring they are meeting the required quality.

Collaborating with their members will also allow for aggregation of the avocados increasing both trading volumes and bargaining power. It will also make the process of certifying members less costly.

#### 4.1.2 Value chain supporters and their role in the chain

Chain supporters are the stakeholders that provide support services to the chain actors e.g. financial services and technical support. Table 4 highlights the supporters in the avocado value chain in Nandi County and their various roles and responsibilities.

Table 4: Supporters in the avocado value chain in Nandi County

Supporter	Role
<b>Kenya Agricultural and Livestock Research Organization (KALRO)</b>	Technical expertise on seedlings and extension services to farmers. However these services are not adequately provided.
<b>Horticultural Crops Directorate Authority (HCDA)</b>	Regulating production and marketing of horticulture products
<b>Kenya Plant Health Inspectorate (KEPHIS)</b>	Regulate the quality of agricultural inputs and produce
<b>World Bank</b>	Provides technical assistance to farmers under the NARIG (National Agricultural and Rural Inclusive Growth) project.
<b>Equity Bank</b>	Provides funding and technical assistance to farmers under the MasterCard Foundation
<b>Safaricom</b>	Provides assistance to farmers under the DigiFarm platform that provides access to inputs at discounted prices, loans and farming and market information
<b>JICA</b>	Provides technical assistance to farmers on GAP
<b>Nandi County Government</b>	Supports the growth and development of the avocado value chain because avocado has been identified as a priority crop for diversification

Source: Author's own compilation from interviews with different stakeholders

#### 4.1.3 Value chain influencers and their role in the chain

Value chain influencers provide a (dis) enabling environment for the value chain. For example they are responsible for the laws, regulations, standards, and policy frameworks to be adhered to. Table 5 highlights the chain influencers in the avocado value chain in Nandi County.

Table 5: Influencers in the avocado value chain in Nandi County

Influencer	Role
<b>Certification Bodies e.g. GlobalGap</b>	Determine standards and adherence to standards for produce for export
<b>Nandi County Government</b>	Develops the rules, regulations, strategy and agriculture policy for the County
<b>Horticultural Crops Directorate Authority (HCDA)</b>	Regulating production and marketing of horticulture products

Source: Author's own compilation from interviews with different stakeholders

#### 4.1.4 Stakeholders and their roles in assessing ICT readiness

Various stakeholders play different roles in ensuring the development of an integrated ICT enabled chain wide traceability system. This is through their various functions, capabilities, and linkages to other stakeholders. Table 6 summarizes the different roles of the various stakeholders. Indirect stakeholders and business partners in the FORQLAB project are also included.

Table 6: Stakeholders and their role in an integrated traceability system

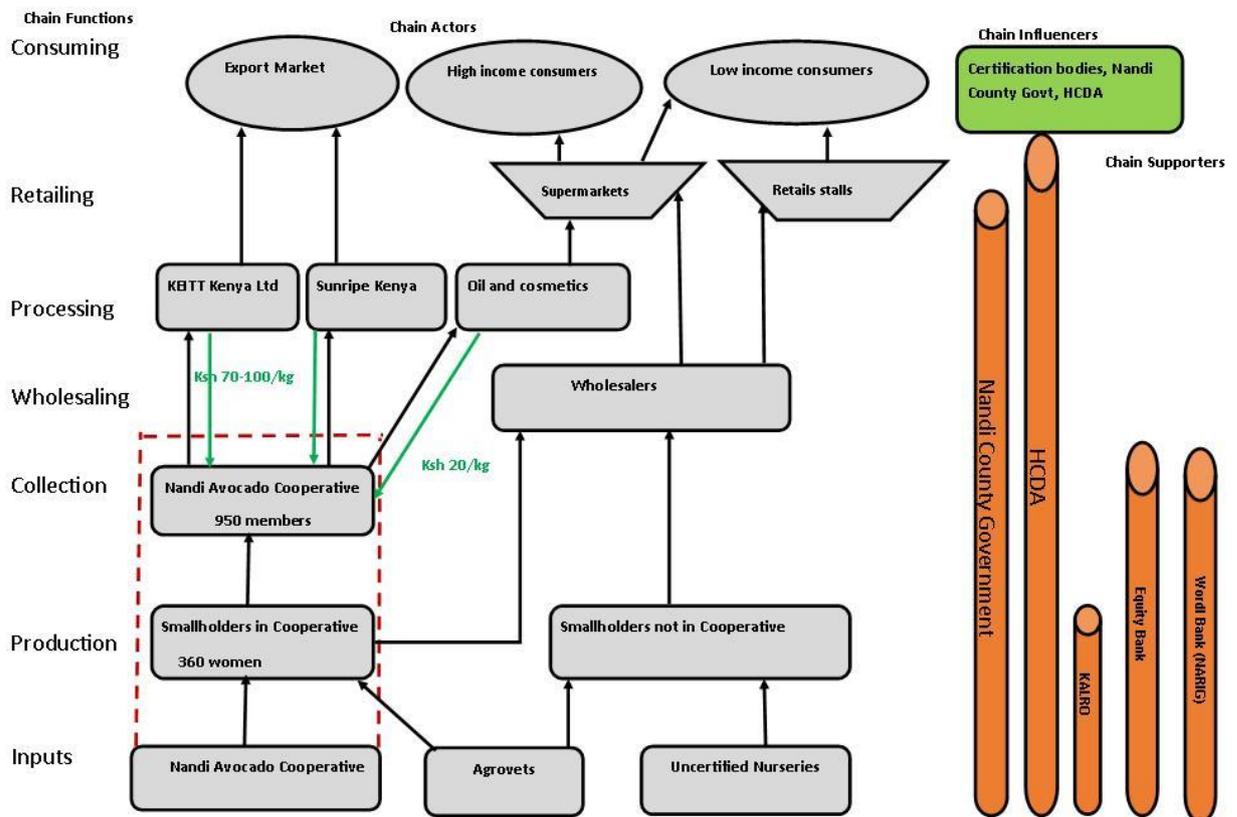
Stakeholder	Role
<b>Chain Actors</b>	Production, marketing and trading of the avocado among the different actors along the value chain
<b>Chain Supporters</b>	Technical support and funding to chain actors to ensure improved production and marketing of avocados
<b>Chain Influencers</b>	Regulate the quality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

Source: Author's own compilation

For the various stakeholders identified in the avocado chain in Nandi County, the value chain map is illustrated in Figure 21. This highlights the product flow in the value chain.

Figure 21: Avocado Value Chain - Nandi County

**AVOCADO VALUE CHAIN—NANDI COUNTY, KENYA**



Source: Author's compilation

## 4.2 Value chain governance of avocado value chain and influence on ICT readiness

### Sub question 2: What is the governance structure of the avocado value chain in Nandi County in supporting ICT readiness?

In exploring this question, 3 facets were explored including: Chain relations, market institutions and information flow. These parameters allowed the examination of the qualitative factors in the avocado value chain in Nandi County and how they provide a (dis) enabling environment for ICT readiness.

#### 4.2.1 Chain Relations

From the study, there is little or no coordination among the various stakeholders in the avocado value chain in Nandi County. For example, the farmers rely on minimal training from Keitt Kenya Ltd and Sunripe Kenya on the quality requirements of the avocados. This leads to farmers incurring losses when their avocados are rejected at the packhouses.

As noted by various interviewees e.g. the farmers and the cooperative's secretary, there are various organizations that offer technical assistance to farmers e.g. the World Bank through the NARIG

project and Equity Bank through the Mastercard Foundation. These efforts remain uncoordinated as each organization strives to achieve its own objectives.

There is some collective action from producers through the Nandi Avocado Cooperative Society, but the benefits of this have not yet been maximized. Farmers note the need to hire more staff at the Cooperative, and this is corroborated by the Cooperative officials.

The lead firms in the value chain are the exporters, Keitt Kenya Ltd and Sunripe Kenya. These companies provide some training to farmers, harvest the avocados when ready and transport them to their packhouse. At the packhouse, grading is done, and it is at this point that quality of avocados accepted and rejected is communicated to the farmers, leading to losses to the farmers due to supplying avocados that do not meet the market quality requirements. Avocados that do not meet quality requirements for export are sold to oil and cosmetic processors for lower prices. According to the farmers, Grade 1 avocados sell for between Ksh. 70-100 per kg. Grade 2 avocados sold to oil and cosmetic processors sell for Ksh. 20 per kg.

Chain relations among the different stakeholders are informal, with no formal contractual obligations. Different stakeholders echoed this e.g. the farmers, retailers, wholesalers, transporters and by the Nandi Avocado Cooperative secretary. These informal relations in the chain mean there is an ambiguity on the quality standards of avocados required. A key farmer confirms this by stating:

We don't understand what dry matter is, we only get blanket warnings (from the buyers) that keep fluctuating. We are only told to look for the right color, and then our fruits get rejected at the packhouse. The only training we get is on the different sizes of the avocados and nothing else about other quality requirements (Choge, 2022)

#### 4.2.2 Market Institutions

The avocado value chain in Kenya is regulated by the Horticulture Crops Directorate Authority (HCDA). This is the organization tasked with overseeing the horticulture sector in the country. In Nandi, the avocado value chain is supported by the Nandi County Government. As noted by the representative from the Nandi County Government's agriculture department, avocado is a priority crop for the county for diversification away from the maize and tea sectors dominating the county. This was reiterated by the farmers who note that due to climate change, more people in the county are venturing into avocado farming for diversification purposes.

As noted by the cooperative officials, farmers and county government representative, various organizations have initiatives offering technical and financial support to the avocado farmers in Nandi County. These include, Equity Bank, JICA, World Bank, Safaricom and KALRO. Stakeholders, from the various interviews however, noted the disjointed nature of engagement among the different supporters and institutions. They further noted the need to have partnerships among the different stakeholders, and particularly in expending efforts geared to equipping farmers to be able to access the markets more effectively e.g. through training and certification.

### 4.2.3 Information Flow

Various types of information flows in the avocado value chain in Nandi County. This was noted by the different stakeholders interviewed. Some of the information include:

**Product:** Farmers and cooperative officials confirm that the lead firms, Keitt Kenya Ltd and Sunripe Kenya control product. The product quality is determined by global certification standards. Many farmers in Nandi County are not certified and as such fail to meet the required product standards. This leads to losses to the farmers as products are rejected. The need for certification and training for farmers was noted by various stakeholders.

**Price:** The price for the avocados is determined by lead firms, depending on the market prices. The farmers noted that they are price takers, as they lack collective bargaining power due to low volumes still being produced. Prices for avocados flowing through the wholesalers and retailers fluctuate, depending on the availability of the avocados. A retailer in Kapsabet confirms that she lowers the prices of avocados if they ripen too quickly and risk going to waste.

**Market information:** Wholesalers and retailers in Nandi County pay the County Government for business and trading permits. Information to avocado farmers is channeled through the cooperative society.

Interviews with the different stakeholders highlighted the centrality of ICT in information flow in the avocado value chain in Nandi County.

- Products orders are made via mobile phones and social media e.g. WhatsApp among wholesalers, retailers, and transporters.
- Payments are effected using MPESA, a mobile money service offered by Safaricom. The Cooperative also uses Eazybizz, a mobile money solution provided by Equity Bank to receive membership fees from members.
- Nandi Avocado Cooperative communicates with its members using social media e.g. WhatsApp messaging, Facebook, and SMS for members with no smart phones. Meetings are physically held quarterly in the different wards in the county, culminating in one annual general meeting (AGM) for all cooperative members.

### 4.2.4 PESTEC Analysis

The PESTEC analysis analyzes the external environment of the avocado value chain in Nandi County in relation to assessing ICT readiness. It analyzes the political, economic, social, technological, environmental, and cultural factors influencing traceability in the value chain. These various factors are represented in Table 7.

Table 7: PESTEC Analysis of Nandi Avocado Value Chain

<b>P</b>	<b>POLITICAL</b>	<ul style="list-style-type: none"> <li>Nandi County coordinates the agriculture policy with avocado being a priority crop for diversification</li> </ul>
<b>E</b>	<b>ECONOMIC</b>	<ul style="list-style-type: none"> <li>Funding from the Nandi County Government</li> <li>Partnerships with different organizations e.g. World Bank, Equity Bank and Safaricom</li> <li>Rising demand for quality avocados in the domestic and export markets</li> <li>Opportunity to get certifications through the cooperative</li> </ul>
<b>S</b>	<b>SOCIAL</b>	
<b>T</b>	<b>TECHNOLOGICAL</b>	<ul style="list-style-type: none"> <li>Increasing use of MPESA for payment services</li> <li>Use of smartphones and social media for communication</li> <li>Improved internet connectivity in the County.</li> <li>Partnership with Safaricom</li> <li>Training on climate smart agriculture practices.</li> </ul>
<b>E</b>	<b>ENVIRONMENTAL</b>	<ul style="list-style-type: none"> <li>Diversification into avocado farming in the County</li> <li>Suitable Climate to grow avocados</li> <li>Avocados intercropped with other crops</li> </ul>
<b>C</b>	<b>CULTURAL</b>	<ul style="list-style-type: none"> <li>Quality avocados are being embraced for their nutritional qualities</li> </ul>

Source: Author's compilation from interviews with stakeholders

#### 4.2.5 SWOT Analysis

The SWOT analyses the internal and external environment of the avocado value chain in Nandi in relation to assessing ICT readiness in adopting an integrated chainwide traceability system. This is illustrated in Table 8.

Table 8: SWOT analysis of Nandi Avocado Value Chain

<p><b><u>STRENGTHS</u></b></p> <ul style="list-style-type: none"> <li>Use of mobile payment systems e.g. MPESA and EazzyBiz</li> <li>Use of social media e.g. WhatsApp for communication among stakeholders in the value chain</li> <li>Availability of smartphones among different stakeholders in the county</li> </ul>	<p><b><u>WEAKNESSES</u></b></p> <ul style="list-style-type: none"> <li>Inadequate training given to farmers</li> <li>Un-coordination among the various stakeholders in the value chain</li> </ul>
<p><b><u>OPPORTUNITIES</u></b></p> <ul style="list-style-type: none"> <li>Leveraging on network connectivity in the county</li> <li>Different partners working with avocado farmers</li> <li>Leveraging on the cooperative membership to get certifications, training and increase bargaining power</li> <li>Increasing demand for avocados both locally and for the export market</li> <li>The opportunity to use Eldoret International Airport for exports.</li> </ul>	<p><b><u>THREATS</u></b></p> <ul style="list-style-type: none"> <li>Hailstorms that damage the avocado trees and affect quality</li> <li>Reliance on rainfed agriculture for avocado production</li> <li>Non certification of avocado farmers to meet export standards for avocados</li> <li>Competition from avocado growers in other Counties.</li> </ul>

Source: Author's compilation from stakeholder interviews

## 4.3 ICT enabled traceability solutions in the avocado value chain

### Sub question 3: What ICT solutions are currently being used for traceability in the avocado value chain?

From interviews with actors in the avocado value chain in Nandi County i.e. farmers, cooperative officials, County Government representative and traders, there are presently no ICT tools being used in the traceability process. ICT tools like social media and mobile payments are being used for administrative purposes, but not for traceability. Traceability for the avocado farmers ends when their harvested avocados are collected by the exporters, Keitt Kenya Ltd and Sunripe Kenya. Records are kept in analog form on cards and paper files at the cooperative office. These records only identify the farmer, variety of avocado supplied and the route name. An example of analog record for farmer identification is illustrated in Figure 22.

Figure 22: Analog farmer records

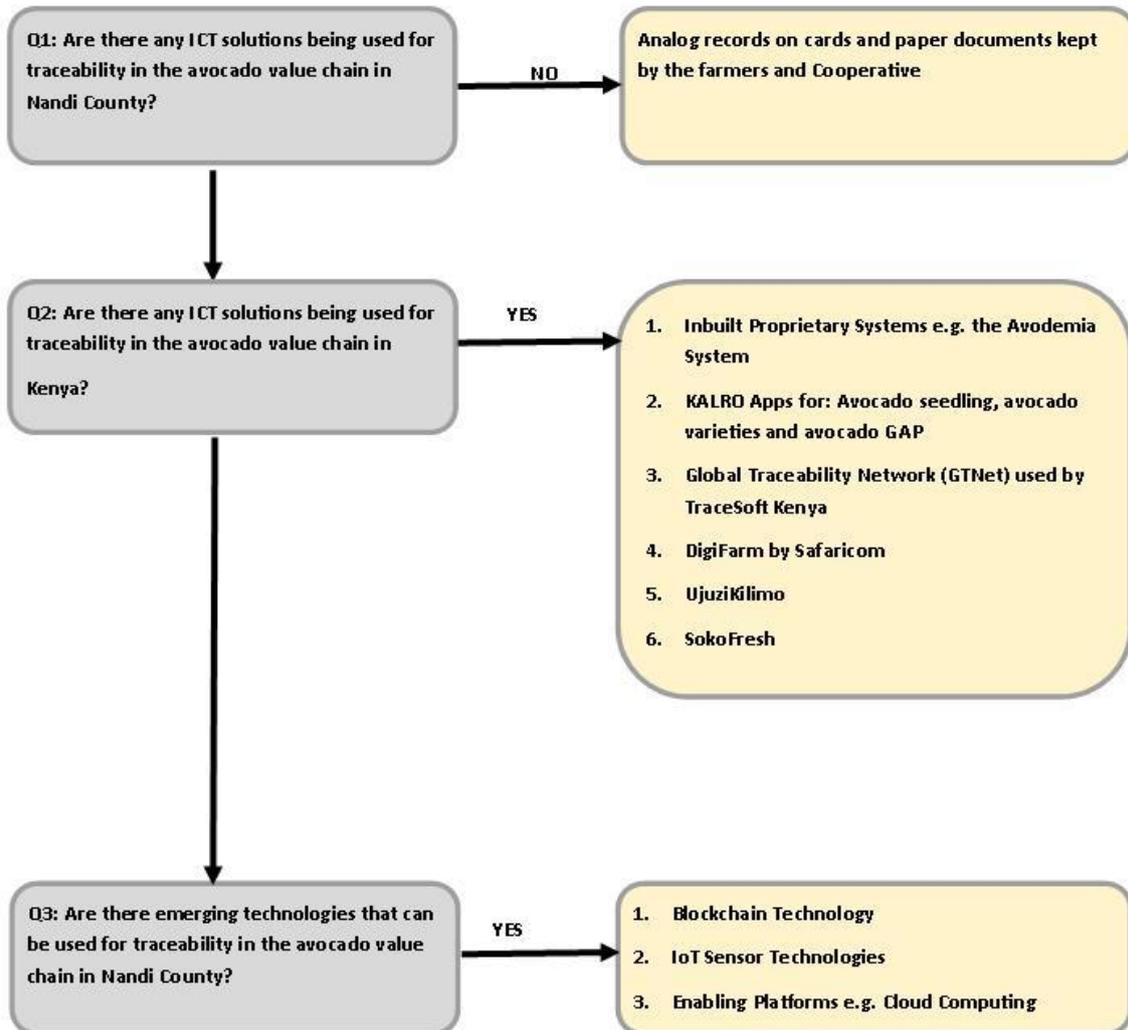


Source: Nandi Avocado Cooperative Society

Interviews conducted with ICT experts in Kenya on traceability options in Kenya, noted that there are ICT enabled traceability options currently being used in Kenya. In addition, there are emerging technologies that can be used to implement an integrated chainwide traceability system in the avocado value chain in Nandi County. The flow chart in Figure 23 illustrates the steps in these options.

Figure 23: ICT Options Flow Chart

ICT Options Flow Chart



Source: Author's compilation based on interviews with stakeholders

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

## 4.4 Preparedness in the avocado value chain for an integrated ICT enabled traceability system

**Sub question 4: What is the level of preparedness among the value chain stakeholders in the avocado value chain in adopting ICT for traceability?**

### 4.4.1 ICT preparedness among value chain stakeholders

From interviews with ICT experts and drawing from the Network Readiness Index, some salient features considered in assessing preparedness among stakeholders in adopting ICT for traceability include the following:

1. Data on prices, quality, quantities, production, and transportation logistics.
2. Internet Connectivity
3. Partnership and Collaboration among stakeholders
4. Trust among stakeholders in the value chain
5. Infrastructure to support implementation e.g. smartphones, transmitters
6. Technical knowledge among the various stakeholders on system requirements
7. Regulatory environment that supports ICT innovation
8. Shared standards among different stakeholders in the value chain e.g. through certification of farmers.
9. Transparency in processes and practices in the value chain
10. Simplified systems that allow for ease of use especially among smallholder farmers.

These features were highlighted and elaborated on by the ICT experts, exporters, international logistics providers and the avocado importing company in the Netherlands. These stakeholders all concurred that traceability must begin at production level, and not arbitrary points in the supply chain. For example traceability for the avocado must begin at land preparation and seedlings used, and not from when the fruit is harvested.

ICT experts interviewed concurred on the use of open-source software, cloud computing and existing sensor hardware and customizing to the needs of the Nandi Avocado value chain. Some of the open-source software and cloud computing options available in Kenya include:

- SketchUp
- AUTOCAD
- Amazon Web Services (AWS)
- Oracle Cloud Infrastructure (OCI)
- Microsoft Azure
- IBM Food Trust chain network
- GitHub

For each of the parameter highlighted, an examination is then made on the (dis) enabling environment present or lacking, this is represented in the matrix in Table 9.

Table 9: ICT Preparedness in Nandi County

Parameter	Preparedness
<b>Data</b>	Insufficient data on aspects like yield per farmer, quality, weight of fruits, prices etc.
<b>Internet Connectivity</b>	Good internet connectivity in Nandi County. The county has partnered with the National Government in the County Connectivity Project (CCP) through the National Optic Fiber Backbone (NOFBI)
<b>Partnerships and Collaboration</b>	Partnerships exist between different stakeholders, but these only target donor projects and not harmonized with other partnerships within the county.
<b>Trust among stakeholders</b>	With no formal contracts, there is generally distrust among the various stakeholders
<b>Infrastructure</b>	Widespread use of smartphones for communication and mobile payment options
<b>Technical knowledge</b>	Extension officers and Cooperative staff are not adequately trained to fully leverage on ICT solutions
<b>Regulatory Environment</b>	There is a commitment from both National Government and County Government to expand on ICT innovations in the agriculture sector using emerging technologies. The Ministry of ICT established a Blockchain and Artificial Intelligence Taskforce in 2018. Its 14 members include experts from Safaricom, Cisco, IBM Research Africa, the African Development Bank, as well as tech entrepreneurs and consultants. This group has urged Kenya's government to invest in blockchain and AI infrastructure and skills, as well as to regulate the two technologies.
<b>Shared Standards</b>	Low levels of certification among smallholder avocado producers in Nandi County impedes the acceleration to adopting ICT for traceability.
<b>Transparency in processes</b>	Opacity in the value chain among stakeholders as they protect proprietary information may curtail the adoption of an integrated chainwide traceability system.
<b>Simplified systems</b>	Easy in developing mobile Apps in Kenya would provide the opportunity to develop a simplified system for all stakeholders, and especially the smallholders.

Source: Author's compilation from interviews with stakeholders

The study then compared the sustainable business models between Nandi Avocado Cooperative Society and the Mexico Avocado value chain. This comparison not only did an end-to-end comparison of the producer organizations but compared a developed chain in Mexico to a developing chain in Kenya. This aided in identifying gaps in the business models that could be improved on in implementing an integrated chainwide traceability system in Nandi County.

#### **4.4.2 Triple Layered Business Model Canvas for Producer Organizations - Sustainability**

The triple layered business model canvas was used to detail the business models of the avocado value chains in Nandi County and Mexico. This allowed insights into the 3Ps of sustainability – people, planet, profit, as pertains to the avocado chains.

##### **Triple Layered Business Model Canvas - Nandi Avocado Cooperative Society**

The TLBMC of Nandi Avocado Cooperative Society highlights an avocado chain with business partners not coordinated and pursuing different interests in various projects. There is no processing done by the cooperative and avocados are produced in different grades for the local and export markets. Farmers are not certified, and this leads to up to 60% in avocado losses. There is also a shift to avocado farming by farmers in the county as the value chain continues to develop. Traceability in the chain ends when the exporters harvest and process the avocados at their packhouses. Annex 16 illustrates the different layers of the TLBMC of Nandi Avocado Cooperative Society.

##### **Triple Layered Business Model Canvas - Association of Avocado Exporting Producers and Packers of Mexico (APEAM)**

APEAM's TLBMC highlights a well-developed and organized chain. All the stakeholders are formally registered and organized into 39 different municipalities and export of avocados is only possible through the APEAM. Traceability commences with the availability and use of certified seedlings and registered orchards. All smallholder farmers are integrated into the chain through mandatory registrations. Traceability therefore begins at production. Figure 11 highlights a well-organized and coordinated value chain with end-to-end traceability. However, due to the lucrative business that is the avocado business in Mexico, it has led to an increase in organized crime as cartels seek to control the production and trading of avocados. Annex 17 illustrates the different layers of the TLBMC of APEAM.

# CHAPTER FIVE



# CHAPTER 5 DISCUSSION

This chapter discusses the findings from the study from the various interviews conducted. The discussion is presented in the sequencing order of the research sub questions as this allows for logical examination and presentation of the results. The findings are discussed while comparing and contrasting the findings between the different stakeholders interviewed and from relevant literature on ICT readiness in adopting an integrated chain-wide traceability system.

All the research sub questions are discussed in the context of the research objective – assessing the readiness in adopting an ICT enabled, integrated chainwide traceability system.

Some of the tools used to present the discussion of results include the Mendelow’s Stakeholder Matrix.

## 5.1 Value chain stakeholders and their role in the avocado value chain

Sub question 1: What are the responsibilities, interests and power of the various actors, supporters, and influencers in the avocado value chain in Nandi County?

### 5.1.1 Value chain actors and their role in the value chain

The study found various stakeholders involved in the avocado chain in Nandi County, and their readiness to adopting and ICT enabled integrated chainwide system varied.

Serem (2022), chairperson of the Nandi avocado cooperative society noted that records were still in analog form, in paper cards and records kept by farmers and the cooperative. This was confirmed by the marketing coordinator at the cooperative who further noted that that even though there was presently no traceability after the production level, they would like for a digitized system that identifies avocados produced in Nandi County. “We want the buyers to know the source of the avocados so that they can enjoy the fruits coming from Nandi County” (Tirop, 2022)

Jerop (2022), agriculture officer at Nandi County Government asserts that farmers are all supplied with certified seeds. However, Okochil (2022) a farm manager for a seedling nursery in Nandi County confirms that they sell both certified and uncertified seedlings. Choge (2022), a lead farmer also confirms the existence and use uncertified seedlings by farmers in the county.

An ICT expert noted the need for traceability to begin at production processes and not at random points in the supply.

One of the things that people do not understand is that traceability starts at farm level at the production system. Tracking is done on such parameters as temperature regulation, lighting, air conditioning for controlled room agriculture, and switching on and off of water pumps at intervals. All these are done to ensure and enhance food quality and safety. (Bett,2022)

This is echoed by one of the lead farmers who states:

Training is required to understand the entire process from land preparation e.g. digging of holes for planting, proper composting of manure to ensure proper root development. Training is required from day 1 and should start with proper seedling acquisition. This is important to control and to avoid ruining our reputation as

producers. There also needs to be a cold storage immediately after harvest. Currently no traceability after Sunripe harvests the avocados. (Choge, 2022)

Traceability must then continue after production as noted by one of the FORQLAB business partners.

We would of course need to make sure that that is a cool truck we could bring it into. And I think then in that truck you could have a have a data logger, you could have a monitor on that truck that would make sure that the temperature is right. And then once it gets to a bigger facility where you actually pack and consolidate. (Kristensen, 2022)

In the avocado value chain in Nandi County, the avocados are harvested and transported by the 2 exporters operating in the County, Sunripe and KEITT. At their pack houses, grading is then done and fruits either accepted or rejected, at the cost of the producers.

A study by Chemeltorit et al (2018) on traceability in the horticulture sector in Kenya under the 3R project, noted that most smallholders do not realize that traceability exists or understand its importance. This is however not the case in Nandi County; smallholders are aware of the need to have traceability, so as to meet export market standards.

Jerop (2022) an agricultural officer at Nandi County Government, notes that while farmers are aware they need training on traceability and GAP to support this, there are insufficient extension services available to meet all farmers' needs. A processor and exporter of avocados, also notes that farmers are now aware of the need for certification and traceability.

We also want to keep improving our quality control, by ensuring our farmers are trained and certified. Most farmers are now knowledgeable on certifications because they know it is the only way they will access export markets. (Njoroge, 2022)

Avodemia Ltd based in Ruiru was visited to understand the processing and exporting functions, because there was no access to Sunripe and KEITT facilities who work in Nandi County. According to HCDA (2022), all industry players, including exporters must be licensed after complying with industry standards. This is the justification for mirroring the operations of Avodemia to those of Sunripe and KEITT; all exporters undergo the same licensing process, so the core functions are comparable.

Karippacheril et al (2017) note that markets, and especially export markets can exclude smallholders as they lack the resources to meet markets standards that are strict.

Along the avocado value chain spectrum in Nandi County, it is noted that there is no traceability among the various traders and transporters in the chain. Avocados are also sourced from other towns like Kisii and Webuye and included in the stocks being purchased and sold.

Traceability systems are formally integrated into the chain at the exporter level and even then, these are proprietary inbuilt systems tracking the information required by the exporters. This is evidenced by the systems used by Avodemia Ltd.

It is an inbuilt, inhouse system which ensures we are tracing our avocados from the farmers to when we sell to the market. Payments are also tracked in this system. Traceability is difficult to implement especially when you talk about an integrated system. This is because it is expensive and some information e.g. prices is

confidential only between some parties e.g. the exporter and importer. (Njoroge, 2022)

The overall picture that emerges underscores the lack of traceability system in all the value chain actors and processes. It however highlights the awareness among the value chain actors, particularly the seedling suppliers and producers on the importance of producing avocados that can be traced back to the source.

### 5.1.2 Value chain supporters and their role in the chain

Value chain supporters identified in the avocado value chain in Nandi County are highlighted in Table 4. They include research institutions e.g. KALRO, regulatory bodies e.g. KEPHIS and HCDA, financial institutions, funded projects e.g. Nandi County Government, JICA, Safaricom and World Bank through the NARIG project.

The National Agricultural and Rural Inclusive Growth (NARIG) project by the World Bank has the most visibility in the county. According to the World Bank (2022), the NARIG project aims at increasingly agricultural profitability and productivity in rural communities in the counties selected.

Choge (2022), Serem (2022), Jerop (2022) and Tirop (2022) all reference the technical assistance the avocado farmers in the county have received through the NARIG project. The specific technical assistance received could not however be independently verified by the study. They also noted the need to form stronger partnerships among the various supporters so that farmers can get adequate training and allow them access markets.

The support to farmers is channeled through Nandi County Government and then trickles down to the Nandi Avocado Cooperative Society and eventually to the farmers. Serem (2022) noted that with this trickle down, the resources that eventually reach farmers are not always adequate. There is no coordination among the various supporters, as each monitor their own projects and at their levels of interest. E.g. KALRO only monitors seedling traceability from the nursery to the avocado farms.

I argue that with more support and involvement and coordination among the various supporters, avocado producers would be better integrated into a traceability system through such schemes as certification. This is supported by a study by Karippacheril et al (2017) who note that networks and PPPs can help finance traceability systems in ways that include smallholders. They also note that producer groups and group systems may ease constraints that smallholders face in accessing markets.

### 5.1.3 Value chain influencers and their role in the chain

Table 5 illustrates the various influencers in the avocado value chain in Nandi County. These include the Nandi County Government, HCDA and certification bodies e.g. Global Gap.

Farmers who are certified have access to export markets. Certifications are also integral in an integrated traceability system as they allow for shared standards. This is a sentiment aptly noted by the Business Development Manager at Avodemia Ltd.

Certification is key to developing such a system because then it means all the stakeholders are being subjected to the same standards. Certifications are key to transparency in the value chain. For example, all players have to adhere to the same GAPs e.g. IPM. That way traceability will be for a similar product. (Njoroge, 2022)

Serem (2022) notes that there are up to 60% losses for farmers because they are not certified and thus their avocados do not meet the export quality required by the exporters. Fruits not meeting export quality are either rejected on the farm by the producer, or at the pack house after grading.

Jerop (2022) also notes that rejected fruits (because of odd shapes, small sizes of bruises) are used to process oil or sometimes just thrown away when not purchased by oil processors. She also noted that extension and support services by the HCDA and Nandi County Government were not adequate to reach all farmers.

This is also observed by a lead farmer who notes:

Most farmers are not aware of the standards for export and training is only on sizes, but not on other quality requirement. The rejection rate at the pack house is quite high because fruits are not tested on the farms. We have no training on dry matter and all we get are blanket warning which keep fluctuating. Most farmers are not aware of the correct dry matter content and how to test for it. We are only to observe the color of the fruit and that's not adequate. Maybe we can advance further and get a tester at the cooperative so that fruits are not harvested before they are mature. (Choge, 2022)

Lead farmers are the voice of the farmers in the value chain as they also hold official roles in the cooperative society. Their sentiments and opinions are highly regarded in the context of the Nandi avocado chain. The echoes of inadequate training in among producers is in my guided opinion a matter that requires intervention in the process of adopting an integrated ICT enabled traceability system. Farmers cannot adopt or implement that which they do not know.

#### 5.1.4 Stakeholders and their roles in assessing ICT readiness

The various actors, supporters and influencers in the avocado value chain play different roles in the traceability system.

I posit that for an integrated, ICT enabled chainwide traceability system, all the different stakeholders are key to achieving this end. Seedling suppliers ensuring provision of certified seedlings will ensure farmers are producing quality export ready avocados. Collaboration among the various supporters and influencers will ensure that dissemination of information is homogenous along the chain, emphasizing the need to produce quality and traceable avocados.

Gichoga (2022), an ICT expert observes that the fragmentation in traceability system in the avocado value chain in Nandi County can be addressed by having a modular approach in the traceability in the value chain.

According to Sonogo et al., (2018) modularity breaks the product architecture into physically independent units. They further note that the idea behind a modular design is to allow the combination of distinct modules – through defined interfaces – to compose products. This concept implies that inasmuch as the different components act individually, they combine to form a cohesive product.

Those individual components can then address their niche and provide visibility to the overarching solution. This modular approach allows the abstraction of complexities of the execution to the

individual value chain functions. Information needed for each of the functions can therefore be easily defined. This is a process that can address the fragmentation in the avocado value chain in Nandi County.

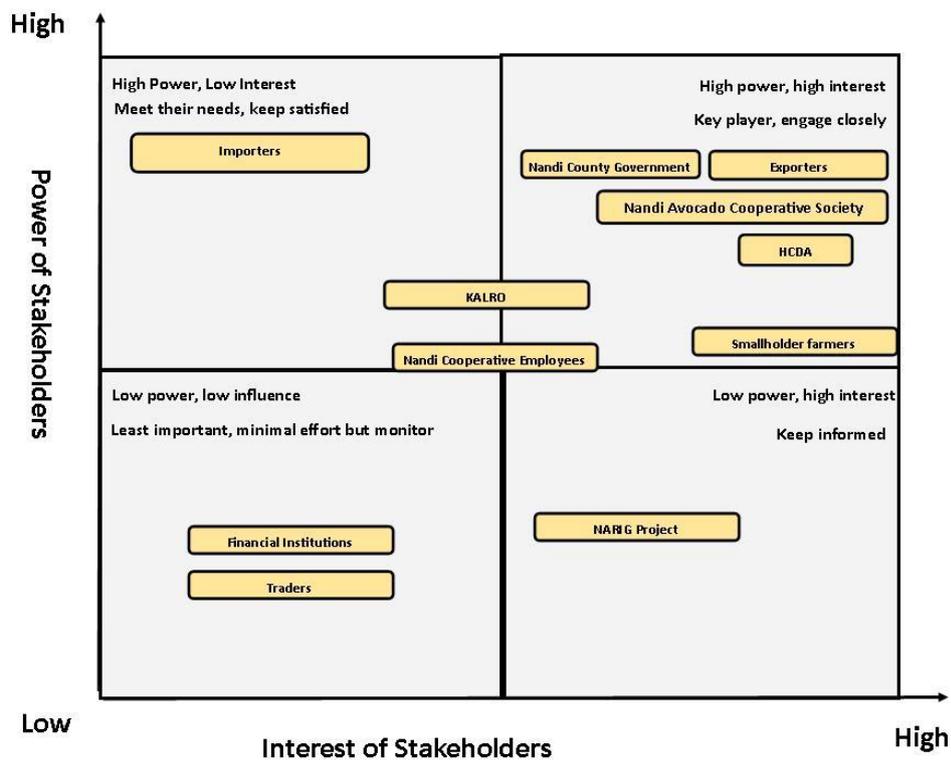
However, each stakeholder, at different levels must play their respective roles highlighted in Table 6. This coordination is best described with this statement as refers to this study:

I like your project and even though it is complex and there are many players involved, when everyone starts singing in harmony it is going to be a beautiful thing to see. This is why using the modular approach, start breaking it down in layers at different levels of operations and then at each of these levels and layers, players are allowed to define and innovate in how they define their challenges and solutions. But there needs to be common language so that similar information is exchanged. (Gichoga, 2022)

Babatunde (2018) asserts the need for each stakeholder to collaborate so as to assist the smallholders meet traceability requirements. Traceability and certification are demanded by exporters and is a requirement to access the export markets. This is a challenge that most smallholders in Kenya still grapple with.

The power and interest levels of the various stakeholders in the Nandi avocado value chain are shown in Figure 24 and illustrates the key players to engage closely.

Figure 24: Mendelow's Stakeholder Matrix for Nandi Avocado Chain



## 5.2 Value chain governance of avocado value chain and influence on ICT readiness

### Sub question 2: What is the governance structure of the avocado value chain in Nandi County in supporting ICT readiness?

Market Links (2022) defines value chain governance as the relationships among the different stakeholders in a chain and their range of activities required to move a product along the value chain, from production to end use. It is about power and influence along the chain and it is observed that in the value chain, there is a lead firm, i.e. the firm that sets the parameters under which other stakeholders operate.

In the Nandi avocado value chain, the exporters are the lead firms. They control the prices, flow of product and information and the production processes. Sunripe and KEITT harvest and collect avocados from the farmers and transport them to their pack houses. Serem (2022) confirms that KEITT buys all varieties of avocados – Hass, Fuerte and the traditional varieties. However they will most times leave the rejected fruits in the farms after harvest, a loss to the farmer. Sunripe on the other hand purchases Hass variety and will ascertain the accepted and rejected quantities, after grading at their pack house. The farmers have no control over the price and quality parameters used by the exporters.

The 5 types of value chain governance structures are represented in Table 10.

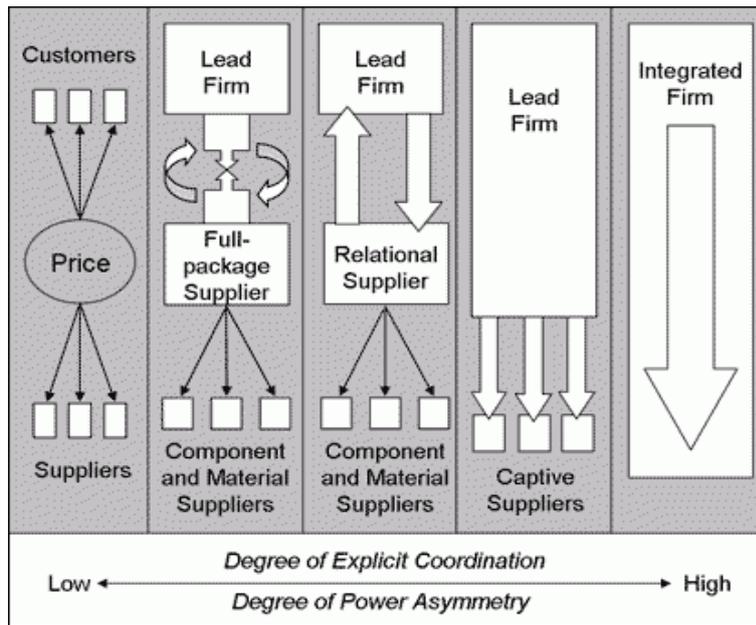
Table 10: Types of value chain governance structures

Type	Characteristics
Market	Simple transactions; product information easily shared; producers don't need a lot of input from buyers before production.
Modular	Firms undertake complex transactions but are relatively simple to categorize.
Relational	There is transfer of information and embedded services by the firms in the value chain.
Captive	Smallholders are dependent on a few buyers who control the market and market information.
Hierarchy	There is vertical integration and control by lead firms; they control the product from production to end use.

Source: Adapted from Marketlinks.org (2022)

From the operations in the Nandi County avocado value chain, there is a captive type of structure because the market is controlled by the 2 exporting companies, Sunripe and KEITT. Figure 25 represents the various types of governance structures.

Figure 25: Value Chain Governance Structures



Source: Marketlinks.org (2022)

### 5.2.1 3R Governance Framework

To have an insight into the various parameters of value chain governance between a developed and a developing value chain, the parameters of:

- Chain relations
- Market Institutions
- Information Flow

were compared for the Nandi avocado cooperative society and the Association of Avocado Exporting Producers and Packers of Mexico (APEAM) in the 3R Framework. This is illustrated and explained in Table 11. Whereas APEAM has a well-coordinated traceability system, Nandi avocado society still needs to expend efforts into stakeholder coordination and collaboration to achieve an integrated traceability system.

Table 11: 3R Governance Framework for Nandi and APEAM

	Nandi Avocado Cooperative Society	APEAM
<b>Robustness (Chain relations)</b>	There are 2 lead firms and many partners in the chain. However, there is un-coordination among the various stakeholders.	All 30,000 smallholders must be registered in the 39 municipalities. Export of avocados is only possible through the APEAM. There is excellent coordination in the chain through the APEAM
<b>Reliability (Institutional Governance)</b>	Partnerships exist with various stakeholders e.g. NARIG, JICA and Equity Bank. However these are not coordinated as each stakeholder focusses only on their project outcomes	All the partnerships with various stakeholders are coordinated through the municipalities and APEAM.
<b>Resilience ( Innovation, technical expertise)</b>	Inadequate technical assistance and extension services to smallholders to allow for end to end traceability in the value chain.	Traceability is fully embedded at all steps in the value chain, from use of certified seedlings to traceability crates and stickers from production to the end market.

Source: Authors compilation

### 5.2.2 PESTEC Analysis

Analysis of the external environment of the Nandi avocado value chain highlights the enabling environment to enable an ICT enabled integrated traceability system.

#### **Political**

Avocado is a priority crop for diversification in Nandi County and therefore efforts are being expended to ensure the value chain is developing. This is noted by Jerop (2022) an agriculture officer in the County Government and confirmed by Serem (2022), Chairman of the Nandi Avocado Cooperative Society and Choge (2022) a lead avocado farmer in the County. Mukasa (2022), an ICT expert notes that at a macro level, the Government of Kenya is committed to providing a regulatory environment and skills development in the counties to allow for the adaptation of innovative technologies.

#### **Economic**

The rising demand for Kenyan avocados in the global market present the opportunity to develop and scale up this value chain. Core to this will be certification and traceability so farmers are able to meet market requirements as noted by an ICT expert in the study.

There is the need to start from the beginning and have data in a synchronized and uniform way. For the farmers it would be better if traceability is digitized because it makes it easier. For the cooperative, it also makes it easier because with the push of a button they can get better insights on different information in the market, monitor trends and then move to the next level in the supply chain. (Tenhagen, 2022)

Partnerships will be key to achieving certification and an integrated traceability system, a key point that is echoed by Mukasa (2022) and emphasized by producers, cooperative officials, and other ICT experts. I argue that the enabling economic environment will be better harnessed with strengthened and coordinated partnerships among the different stakeholders in the value chain.

#### **Technological**

Various technological aspects provide an enabling environment to an integrated traceability system. These include the extensive use of MPESA as a payment system, meaning many smallholders already are using mobile phones that can be used in an ICT enabled traceability system. However, ICT enabled traceability system is data rich and requires internet connectivity as noted by the ICT experts interviewed for this study. A dis-enabling technology environment e.g. inadequate connectivity in all areas of the county would hinder the effective adoption of such a technology. For this study, the connectivity penetration was not examined and thus cannot be concluded that the entire County has good network connectivity.

#### **Environmental**

Nandi has a good climate that allows for rainfed avocados to be produced year long. This mirrors the Mexico chain that is also ecologically advantaged to produce avocado year-round. This then, incentivizes the farmers and other stakeholders in the value chain to effect measures such as certification and traceability to be able to access global markets by producing avocados that meet market requirements.

## Cultural

The rising demand, in both the local and export market, for safe and quality avocados, provides an impetus to adopt an integrated traceability systems in the value chain.

### 5.2.3 SWOT Analysis

The SWOT analysis for Nandi avocado value chain highlights some strengths and opportunities that can leveraged upon to adopt an ICT enabled traceability system. These include the prevalence of mobile payment service, MPESA by stakeholders in the County, including smallholders. There is also good network connectivity in Nandi County, and this would allow for an ICT enabled system. However the exact internet penetration was not assessed by this study, and thus cannot be concluded from the study, the extent and strength of internet connectivity in enabling a traceability system.

This is supported by Mukasa (2022), an ICT expert who noted that some of the issues to be addressed to allow for adequate preparedness in the County include last mile infrastructure (ensuring internet connectivity to all users in Kenya, including those in the rural areas) and a lack of adequate digital skills among all stakeholders in the county.

The need for training on various aspects on market requirements necessitating traceability and certification is noted by different stakeholders in the county including the producers, exporters, and importers. A Supply Chain Manager for an avocado importer in the Netherlands however asserts the importance of having farmers interested in being trained. He observes:

The big question, do they want to have that knowledge? We work with some smallholders, but most say lovely I know where my avocados are going, but at the end of it, all they are interested in is the money and getting paid. We have 3 tiers of farmers, from Tier 1 to 3 and tier 3 are the farmers who really want to evolve to entrepreneurship (Schoemaker, 2022)

He further notes the importance of cooperative in training farmers and allowing them attain certification standards.

There are definite benefits of working in cooperatives: it is easier to upscale, with farmers working together there is cooperation and collaboration, it is easier to get certification due to the larger numbers and things like inputs will be cheaper.

It is important to note the willingness of farmers in Nandi County to get training to achieve market requirements, and this is core to deployment of any training by the cooperative and other partners in the County. The Chairman of the Nandi avocado cooperative notes:

Nandi avocado farming is now an agribusiness. People are seriously doing it as a business to assist families. Some farmers have old avocado trees of local varieties that are 25-40 years old. They are now transforming it to a business by planting the varieties that are required by the market. (Serem, 2022)

## 5.3 ICT enabled traceability solutions in the avocado value chain

### Sub question 3: What ICT solutions are currently being used for traceability in the avocado value chain?

Presently, there are no ICT enabled tools being used for traceability in the Nandi avocado value chain. Records are kept on paper cards and documents by the farmers and the cooperative.

However, interviews with ICT experts in Kenya highlights the availability of non-integrated ICT solutions at various levels in the avocado chain in Kenya. These are highlighted as follows:

Table 12: ICT traceability solutions available in Kenya

ICT SOLUTION	DESCRIPTION
<p><b>KALRO AVOCADO APPS</b></p> <ul style="list-style-type: none"> <li>• KALRO Avocado Seedlings</li> <li>• KALRO Avocado Varieties</li> <li>• KALRO GAPs</li> </ul>	<p>These Apps are available to be downloaded on mobile phones and give detailed information on different varieties of avocados, seedlings and how to cultivate certified seedlings and GAP guidance on avocado production . KALRO is also able to monitor the details of the users of the Apps and offer more detailed information to users if requested.</p>
<b>SOKOFRESH</b>	<p>SokoFresh offer a first mile (from production to the market) for produce in a pay as you store model. Smallholders pay only for the cold storage space they use. It also offers market linkage to smallholders by integrating them into value chains. E.g. market is found for produce that is harvested and stored by SokoFresh.</p>
<b>UJUZIKILIMO</b>	<p>UjuziKilimo provides agricultural data to smallholders by using sensor technology and farm data analytics . This includes such information as soil testing , GAP, crop calendars, weekly weather updates, market data and linkages. Their payment models range from \$5—\$14.99 per month/ farmer . See Annex 18 for the various models.</p>
<b>DIGIFARM BY SAFARICOM</b>	<p>This is a free service by Safaricom that offers farmers a hub for information on agronomic practices, a learning platform, access to loans and market linkages.</p>
<b>GTNet (Global Traceability Network)</b>	<p>This is a subscription service offered by TraceSoft Kenya Ltd, that allows for end to end traceability in value chain. Presently, this is being used in the flower and coffee industries in East Africa.</p>
<b>CUSTOMIZED SYSTEMS</b>	<p>These are inhouse, customized systems used by stakeholders in the avocado chain, to track information they deem important to them e.g. the customized system used by Avodemia Ltd.</p>

Source: Author's compilation

In addition, all the ICT experts interviewed for the study highlight the following as emerging technologies that can be used to develop an ICT enabled integrated traceability system in the avocado chain in Nandi County. These are further discussed in Chapter 6, in answering the main research question for the study and are mentioned in Figure 26.

Figure 26: Emerging Technologies for traceability systems

- 
1. **Blockchain Technology**
  2. **IoT Sensor Technologies**
  3. **Enabling Platforms e.g. Cloud Computing**

Source: Author's compilation from interviews with ICT experts

## 5.4 Preparedness in the avocado value chain for an integrated ICT enabled traceability system

**Sub question 4: What is the level of preparedness among the value chain stakeholders in the avocado value chain in adopting ICT for traceability?**

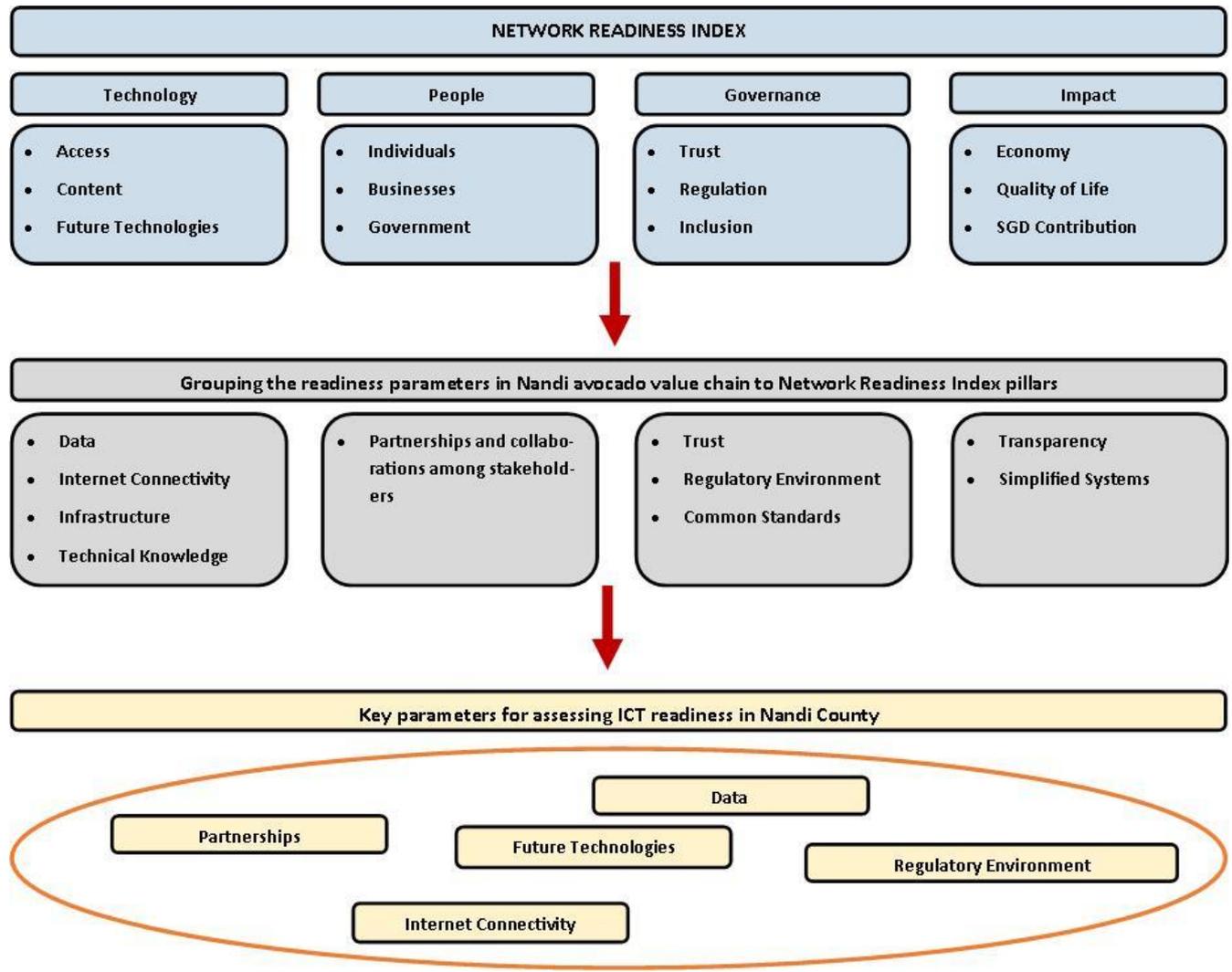
### 5.4.1 ICT preparedness among value chain stakeholders

At country level, the Network Readiness Index (NRI) is used to assess the readiness of a country in adopting technology. This is illustrated in Figure 12. The 4 NRI pillars were applied in interviewing the ICT experts for this study. From their insightful perspectives, 10 key parameters were identified in assessing the readiness of the Nandi avocado value chain in adopting an ICT enabled integrated chainwide traceability system. These are highlighted in Table 9. These 10 parameters were then assessed against the NRI pillars, and the result was 5 parameters to be used in assessing the ICT readiness in the Nandi avocado value chain. These 5 parameters address all the components identified in the NRI as being key to ICT readiness assessment. The 5 key parameters identified include:

1. Partnerships and collaboration among stakeholders
2. Data
3. Internet Connectivity
4. Regulatory Environment
5. Future Technologies.

This trickle down from the Network Readiness Index (NRI) to the Nandi avocado value chain is illustrated in Figure

Figure 27: ICT readiness assessment for Nandi avocado value chain



Source: Author's compilation

These 5 parameters are further discussed:

### 1. Partnerships and collaboration by different stakeholders

As detailed in the research findings, there are various supporters and influencers in the Nandi avocado value chain. However their efforts are uncoordinated as there is the focus on individual projects. I posit that having a functional cooperative society under which to coordinate activities in the value chain is a great opportunity that has not well been harnessed.

Traceability, as observed by Schoemaker (2022), Njoroge (2022) and Kristensen (2022) is hinged to smallholders being certified. They also note the prohibitive costs to certification, and the role cooperatives can play in enabling farmers to be certified.

The cooperative can also leverage the technical assistance from various partners, to avoid duplication of efforts. E.g. in training on the same things by different partners. Choge (2022) aptly stresses the role of partnerships and collaboration by saying “when we work together, we achieve

much. Our volumes can be aggregated, and we can also be certified. If I succeed, you succeed” in reference to need for strengthened partnerships.

From the various avocado producers interviewed, it was evident that collaboration and partnerships need to include farmers not as beneficiaries, but as partners in the value chain development process. Schoemaker (2022) notes the FairTrasa Holland BV model where profits are shared 60%/40% between farmers and the company, respectively. This allows the farmers ownership into production processes because their earnings are hinged on their productivity.

## **2. Data**

From the study, it is evident that data is core to an integrated ICT enabled traceability system; it is data that is traced throughout the system. This is supported by Bett (2022) who states that data is the new oil in terms of its value in an ICT enabled traceability system. Kristensen (2022), a global logistics provider in the fresh produce notes the need to obtain, store and track data along the entire value chain. Tenhagen (2022) concurs and also notes some of the data needed as temperature and pH levels.

Presently, farmers in Nandi County do not keep production records and therefore do not have data on such aspects required in traceability as how many avocados a tree provides and average weight of each fruit. As they do not have access to cold storage, the temperature under which the fruits are stored is not monitored after harvest, leading to losses at the packhouses.

Kristensen (2022) and Tenhagen (2022) note that it is not possible to inspect an entire consignment, and this can be done in batches. Gichoga (2022) adds on to this argument by proposing a system where the traceability system is based on transactions with unique identifiers. He elaborates this by stating:

Let’s assume a seller wants to order an avocado batch from a farmer. The transaction will be unique and will contain all the individual components necessary to complete the order. This is the highest point in the hierarchy and cannot be decomposed further. A transaction consists of individual stacks. These stacks provide visibility to the overall safety and quality assurance of the product. They provide insight to the state of the produce or the transaction. In the individual stacks, we can then have observable metrics e.g. weight, temperature, harvesting dates, shipping dates (Gichoga, 2022)

Table 13 highlights the different datasets that are useful, at different levels in the avocado value chain towards an integrated ICT enabled traceability system. ICT tools can then be used to deploy solutions addressing the observable metrics, ensuring end-to-end traceability in the value chain. The table also highlights some of the ICT tools/solutions that can be used at the different levels to capture the different data. The need for such data sets in aiding traceability is also noted by the Chairman of Nandi Avocado Cooperative Society.

The real traceability and who does the best fruit is still a nightmare and we need to find a way to reach farmers for real traceability. For example tea farmers have lot numbers and batches. E.g. a lot number for Nandi County and each farmer will aid in traceability. With lot numbers, batch numbers and farmers contracted, soil tested, it will yield to higher prices. Batch numbers make the avocados identifiable from farm to shop. (Serem, 2022)

Table 13: Datasets in the avocado value chain

Stack Number	Stack Definition	Observables/Metrics	Possible Solutions
1	Seed to Harvest	<ul style="list-style-type: none"> <li>• Certified Seedlings</li> </ul>	<ul style="list-style-type: none"> <li>• Certified seedling providers and sensor technology in monitoring production processes e.g. chemicals used</li> </ul>
2	Produce Quality Control	<ul style="list-style-type: none"> <li>• Certification standards e.g. color, size of fruits</li> <li>• Unique farmer identification</li> </ul>	<ul style="list-style-type: none"> <li>• Traceability barcode enabled stickers</li> <li>• Smart phone or web based app running on Blockchain portal</li> </ul>
3	Order Management	<ul style="list-style-type: none"> <li>• Quantity</li> <li>• Unit costs and currency</li> <li>• Avocado type</li> <li>• Origin and destination</li> <li>• Seller and buyer unique identifiers</li> <li>• Unique transaction identifier</li> <li>• Weight of fruits</li> </ul>	<ul style="list-style-type: none"> <li>• Blockchain technology.</li> </ul> <p>This will ensure standardization between the different vendors in a open format accessible to all stakeholders in the value chain.</p>
4	Seller Shipment	<ul style="list-style-type: none"> <li>• Origin and destination</li> <li>• Temperature, pH</li> <li>• Unique identifier for crates</li> </ul>	<ul style="list-style-type: none"> <li>• Sensor technology in chips used during shipments. These can either be single use chips or re-usable chips which the seller may receive back from shipping destination periodically.</li> </ul>
5	Logistics Provider (Truck to Plane)	<ul style="list-style-type: none"> <li>• Real time temperature during transport</li> <li>• Real time tracking of the shipment</li> </ul>	<ul style="list-style-type: none"> <li>• Barcode scanners to verify details of shipment</li> <li>• IoT sensor technology for real time monitoring.</li> </ul>
6	Air Freight	<ul style="list-style-type: none"> <li>• Flight number</li> <li>• Live flight tracking</li> </ul>	<ul style="list-style-type: none"> <li>• Due to aviation rules, tracking, real time isn't possible and can only be done at live flight tracking level.</li> </ul>
7	Logistics Provider (Plane to Truck)	<ul style="list-style-type: none"> <li>• Real time temperature during transport</li> <li>• Real time tracking of the shipment</li> </ul>	<ul style="list-style-type: none"> <li>• Barcode scanners to verify details of shipment</li> <li>• IoT sensor technology for real time monitoring.</li> </ul>

Source: Interview with Gichoga (2022)

### 3. Internet Connectivity

All the ICT experts interviewed noted that reliable internet connectivity is a prerequisite to having a successful integrated ICT enabled traceability system. This is because, such a system is data rich meaning a lot of data is transmitted continuously to different stakeholders and at different levels in the value chain.

Kenya News Agency (2021) notes that all 47 counties in Kenya have internet connectivity through the National Optic Fiber Backbone (NOFBI) project Phase 1 and 2. This means that government services can now be easily accessed at the various government facilities in different counties. However, last-mile connectivity (ensuring all stakeholders in different counties have internet connectivity) for Nandi County was not examined under this study and therefore, it cannot be concluded that all smallholders have reliable internet connectivity.

### 4. Regulatory Environment

According to the 2022 Agility Emerging Markets Logistics Index, Kenya ranks 17 overall in digital readiness, but 1<sup>st</sup> in Africa in digital readiness. The Agility Index is a ranking of the world's top 50 emerging markets on different issues such as digital readiness, domestic and international logistics

opportunities, and business fundamentals. (Agility, 2022). Mukasa (2022) an ICT expert notes that digital readiness assesses digital skills and training, e-commerce growth, startups nurturing, internet access as well as sustainability factors such as renewable energy initiatives and green initiatives.

At country level, Mukasa (2022) further notes the following strides made to allow an enabling environment for ICT innovations by establishment of Blockchain and Artificial Intelligence Taskforce in 2018 comprising of 14 experts from companies like Safaricom, IBM, CISCO, technology entrepreneurs and consultants. Among the recommendations include:

- Use blockchain to track agricultural produce from end-to-end (from seeds to marketplace) and to use AI and analytics to detect fraud, trace unsafe products
- Distribute farming subsidies through a blockchain controlled agri-token
- Introduce blockchain technology to enable customers to trace the supply chain of medication
- Develop a health token incentive to reward citizens who maintain a healthy lifestyle.
- Use blockchain supply-chain networks to flag and report counterfeit goods.

An ICT expert interviewed for the study succinctly notes the importance of an enabling regulatory environment in an integrated ICT enabled traceability system by stating:

Having regulations is actually an advantage. The country that will put in the right regulations concerning the avocado value chain and very quickly and adopt traceability and ICT systems, this is the country that will win this war. Currently, we are winning the small battles by being top exporter in Africa. The real war is in being able to adopt such an ecosystem that promotes safe food for all, and at all times. (Bett, 2022)

At Nandi County level, Jerop (2022) notes the commitment of the county to leveraging ICT in developing its traceability system. She further notes that because the value chain is still at infancy, there is the opportunity to set the right systems. However, no specific engagements have been made with any of the partners to actualize this commitment in any of the technical assistance projects in the value chain.

## **5. Future Technologies**

Emerging technologies identified by the ICT experts interviewed include:

- Blockchain
- Internet of Things (IoT) and sensor Technology
- Artificial Intelligence (AI)
- Enabling Platforms e.g. cloud computing and open-source software

They also noted that technologies are only a tool, and not the actual solution. Gichoga (2022) stresses the need to identify a problem and then identify a technology solution, instead of choosing a technology solution and trying to address a problem using it. He also notes that ultimately the smallholders do not care what technology is used, provided it provides a solution and is easy to use. This is emphasized by Tenhagen (2022) who notes that each player in the value chain has specific roles to play; the choosing and definition of a technology solution lies with ICT experts who then tailor solutions based on information provided by the different stakeholders in the value chain.

Overall, all ICT experts interviewed agreed that no one technology would provide all the solutions and a combination of tools was required to develop an integrated traceability system.

ICT experts offer the following as advantages of using an ICT enabled traceability system using emerging technologies.

- Convenience in capturing and relaying information because information does not need to be edited along different points in the chain.
- Decentralized and distributed: All stakeholders have access to the same information though no single stakeholder owns the tool (s) or the information. This allows for trust and transparency to be established in the chain.
- Immutable: Stakeholders cannot change information in the system as this renders a transaction invalid. This allows for transparency, trust and the establishment of smart contracts once preset conditions are met by participating stakeholders.
- Allows for monitoring of data in real time and corrective action to be taken. Data allows allow analysis of trends for decision making purposes.
- Solutions are customizable and can be scaled to other value chains by use of dropdown menus to select different commodities.

In assessing the readiness of the Nandi avocado value chain in adopting an integrated ICT enabled traceability system based on the 5 parameters discussed, what emerges is the commitment to such a system by having an enabling regulatory environment, reasonable internet connectivity and partnerships that can be harnessed.

There is however insufficient data being collected by producers and other stakeholders in the value chain to support this. The various partnerships in the County are also not coordinated resulting in duplications of efforts e.g. trainings on GAP by multiple stakeholders. Collaboration among the different stakeholders in the County has also not been realized.

#### 5.4.2 Triple Layered Business Model Canvas for Producer Organizations - Sustainability

In comparing the TLBMC for producer organizations in Nandi County and Mexico, learning points from APEAM that Nandi avocado cooperative society can learn from include:

- Formal organization of farmers and farms through the County Government and Cooperatives. This can be done at the 6 wards levels to ensure all farmers are included. This will also ensure aggregation of adequate volumes that allow for traceability measures to be implemented. There also needs to be cooperation and coordination of other stakeholders in the chain.
- Training farmers on market and export standards.
- Hiring of skilled personnel by the cooperative and the farms to ensure accuracy in processes like harvesting.
- Implementing traceability from production processes e.g. use of certified seedlings.
- Certification of farmers so they are adhering to global export standards and are able to access markets.

## 5.5 Limitations

The major challenge in carrying out the study was scheduling and rescheduling of interviews by some of the interviewees. However, this did not negatively impact the research process and findings as adjustment was done. This required flexibility in processing of data collected especially from the tail-end interviews. One ICT expert was excluded from the study because they required anonymity at all stages. Because the study was anchored on ICT and expert opinion was central to the study, the researcher made the decision to exclude the interview findings from the study.

## 5.6 Reflection

### 5.6.1 Research process

I selected this topic for my thesis research to challenge myself in an area that was relevant for both my studies and my work I had identified needed attention when I wrote my spotlight and ODIS papers at the beginning of the APCM program. As I began the research process in concept and research proposal writing, I became very apprehensive when I realized the depth of knowledge required, for which I felt unprepared for.

Three things greatly helped me in the process of developing the research problem – advice and guidance from my mentor and my supervisor, reading a wide variety of literature on the subject and speaking to an ICT expert to understand concepts proposed and presented in literature. Though it took several weeks to finally get a grasp of my research direction, I was finally able to develop my research objectives, conceptual framework and strategy that informed my field work phase of the study. The feedback received during the presentation of the concept note for the research was also invaluable in finally shaping my research design.

### 5.6.2 Research methodology

I adopted a qualitative approach to this study as discussed in the research methodology to aid in collection of in-depth information. The use of ICT in agriculture in Kenya is an emerging field of study and practice, and for which information and research is still evolving. This therefore means there is an array of information available for which a researcher must carefully analyze to find practical application in specific value chains.

Initially, I had intended to interview 10 experts for the study, but during my proposal defense, my supervisor and assessors proposed to increase the number of interviewees to at least 20, and include Dutch business partners, an adjustment I made. This allowed me to collect data from an end-to-end, farm to fork perspective of the avocado value chain and collect richer data. Beginning my fieldwork in Nandi County and then interviewing the business partners in the Netherlands afterwards was a great strategy as it allowed me to collect data in a systematic manner in both content and relevance. For example, understanding the traceability situation in Nandi County allowed me to frame my questions better when interviewing ICT experts as I now had a better knowledge of the value chain.

A common misconception among researchers is that qualitative research is easy; however as Denny and Wekesser (2018) note, intense analytical rigor and skill is required to effectively collect and analyze qualitative data, in a meaningful way. For this study, I learnt how to use the qualitative analysis software, Atlas.ti, as a tool to aid in examining data collected, identifying themes (codes emerging) and then grouping the themes to allow for the research questions to be effectively answered. This was an iterative process, that ultimately allowed for my raw data to be organized into meaningful themes.

To ensure validity and reliability of data collected, I used similar checklists for same categories of interviewees e.g. ICT experts and then triangulated their responses against each other and with literature. When information saturation was reached i.e. no new information was being collected, I was confident the data collected would answer the research questions. 2 of the ICT experts acquiesced to ongoing consultation on the technical aspects of their responses and this allowed me to fully grasp concepts and draw relevant conclusions.

### 5.6.3 Researcher Influence

As I adopted a social constructionism approach, I gained new insights as I carried out my research as I had no pre-conceived notions on what to expect. This objective approach allowed me tailor interview checklists for subsequent interviews to obtain relevant information. My interviewing skills were greatly enhanced as I learnt to actively listen so as to ask probing questions that would allow me to answer the various research questions. During the data collection and analysis, I can confidently say I developed my knowledge in this field by a wide breadth in a manner that will allow for this study to have impact not just on the Nandi avocado value chain, but in other value chains in Kenya as well.

# CHAPTER SIX



# CHAPTER 6 CONCLUSION AND RECOMMENDATIONS

## 6.1 Conclusion

This study was carried out to assess the readiness in adopting an integrated chain-wide ICT enabled traceability solution in the local and export avocado chain in Nandi County. This section presents the answer to the main research question.

**Main research question: What Information and Communication Technologies (ICT) tools can be used to develop an integrated traceability system in the avocado value chain in Nandi County?**

From the research findings and discussion, it is evident that Kenya has made great strides as far as the adoption of technology is concerned. For example, MPESA, the mobile money transfer has been in use in Kenya for 26 years with rural farmers readily adopting this technology for ease of managing their money.

KALRO Apps for various crops are also easily accessed by farmers using mobile phones and with the Government of Kenya's commitment to ensuring network connectivity to all 47 Counties in Kenya, there is a proliferation of technology-based solutions in the agriculture sector in Kenya.

It also emerges that in the Nandi avocado value chain, there is presently no traceability of the avocados produced after the 2 buying companies harvest and collect the fruit from the farms to their pack houses. To have an integrated, ICT enabled chainwide traceability systems, there needs to be concerted efforts to include all stakeholders, right from production, post-harvest handling, logistics management, packhouse procedures (sorting, grading, packing), in a manner that ensures all stakeholders are not only involved but are linked. All stakeholders, processes and procedures need to be linked to allow for an integrated end-to-end traceability system.

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

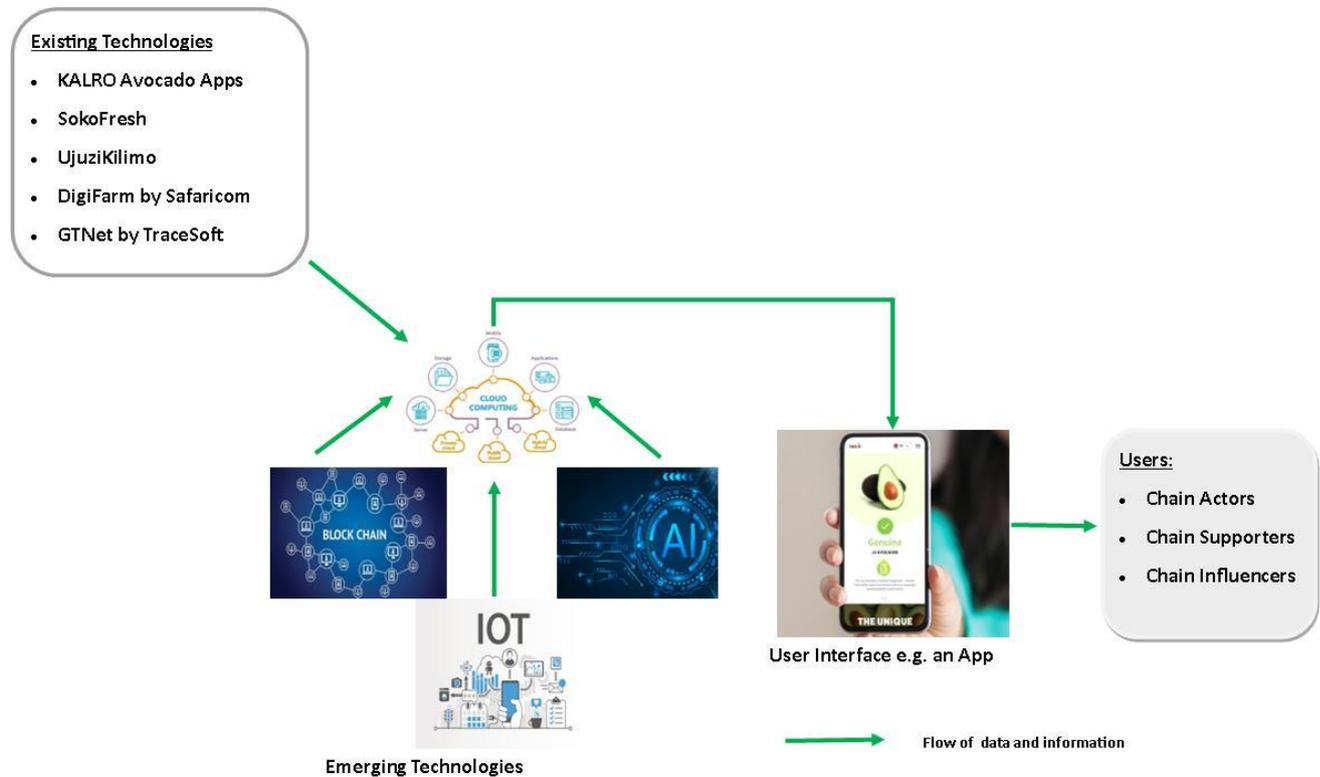
- Information transparency and symmetry, meaning all stakeholders in the chain have access to the same information.
- There is trust among the various stakeholders in the chain and in the information shared among them.
- Transactions must all meet a validity threshold where all stakeholders are able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

These are functions addressed by the emerging technologies like Blockchain which offers immutable, decentralized, and distributed ledgers, meaning information cannot be altered once in the system, is not owned by any one stakeholder, and can be assessed by all stakeholders.

It can therefore be concluded that a hybrid combination of existing and emerging technologies will allow for the development an integrated ICT enabled traceability system in the Nandi avocado chain. By effectively digitizing the existing analog records currently being used by farmers in the Nandi avocado cooperative society and involving other stakeholders in the chain, the way is then paved for the development of an integrated, chain-wide ICT enabled traceability system.

The envisaged hybrid combination between existing and emerging technologies is represented in Figure 28.

Figure 28: Hybrid ICT enabled Traceability System



Source: Author's compilation

Existing technology solutions for traceability in Kenya are fragmented, in that they only address specific functions in the value chain e.g. SokoFresh offering 1<sup>st</sup> mile cold storage solutions, from farm to domestic markets or KALRO Apps providing information at production level. These fragmented solutions can be linked to emerging technologies by all the information from both technologies being distributed using cloud platforms and different stakeholders accessing relevant information through a user interface like an App.

## 6.2 Recommendations

The study points to the readiness of the Nandi avocado value chain to develop an integrated ICT enabled system by combining both existing and emerging technologies. Nandi Avocado Cooperative Society officials indicated the need to have a pack house to address their traceability challenges; however successful adoption and implementation of such system is predicated on The Nandi avocado value chain having a harmonization between technology and chain governance. A pack house in itself will not solve the traceability gap if current analog records are not digitized and there is little or no coordination and collaboration among the various stakeholders in the value chain.

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

1. Technology Intervention
2. Value Chain Governance Intervention

## **Technology Intervention**

The first step in technology intervention includes digitization of the analog farmer records kept by farmers and the Nandi Avocado Cooperative Society, data collection on metrics required in the traceability process e.g. avocado quantities produced per tree, per farmer, average weight of each avocado, quality of avocado produced, registration of farmer details and farms, temperature and pH logs and agronomic practices during the production on avocados. This will allow for traceability of avocados from production level.

After production level, avocados then need to be traced along the various processes in the chain. This can be done using traceability stickers and barcode readers as shown in Table 13. This will then allow for the avocados produced in Nandi County, to be traced from their source in Nandi County and throughout the chain.

Developing a technology solution would require a customization from the existing and emerging technologies and in a manner that includes and links all the stakeholders in the value chain. This is uncomplicated, with the crux of the adoption and implementation being the management of the chain governance aspect of the solution developed.

## **Value chain governance intervention**

Value chain governance interventions include strengthening the partnerships among the various stakeholders in the value chain. A multi-stakeholder approach to traceability ensures proper cooperation and coordination to achieving this objective. Public Private Partnerships (PPPs) will allow for standardization of processes through certification of farmers. Traceability is based on shared standards and certification.

Certification is a costly and lengthy process for individual farmers, but these costs can be significantly reduced if certification is done through the cooperative society. By leveraging on the already existing partnerships in the value chain e.g. the NARIG project, the benefits accrued from stakeholders in a value chain working together will be realized.

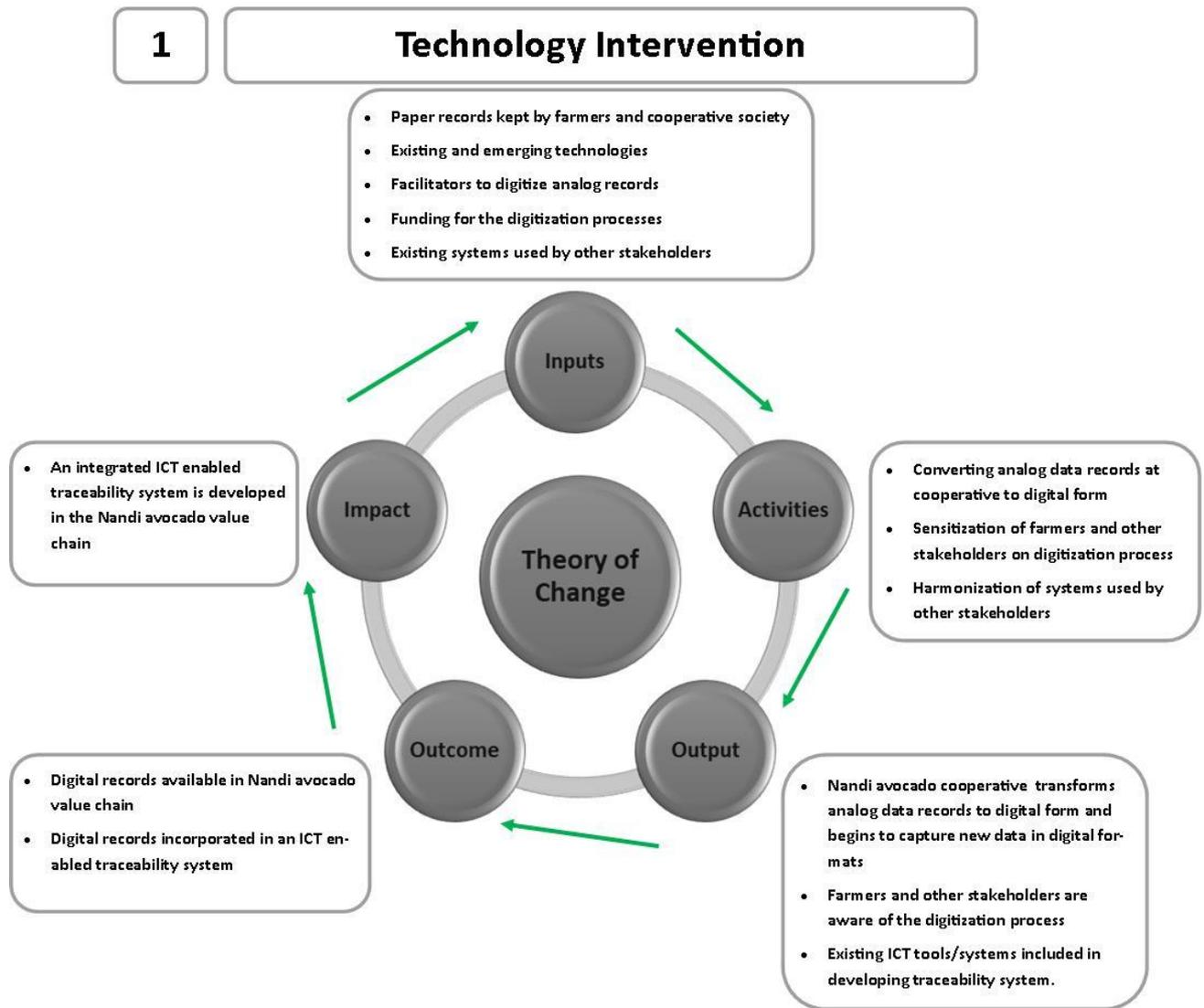
While being cognizant of the power dynamics between the different stakeholders and the shift from an analog to digital approach to traceability, it can also be noted that implementation of these interventions should be gradually done, and in phases and in a consultative manner to both allow for buy in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

### **6.2.1 Theory of Change**

The United Nations Development Group (2022) defines a theory of change (ToC) as a way of explaining how an intervention will lead to a specific impact or development change. A ToC allows for deep analysis of underlying issues, provides a platform for learning and adjustment during implementation, manages partnerships in a project and allows for succinct communication on complex matters.

For the 2 interventions identified for the Nandi avocado value chain, their ToC is illustrated as follows:

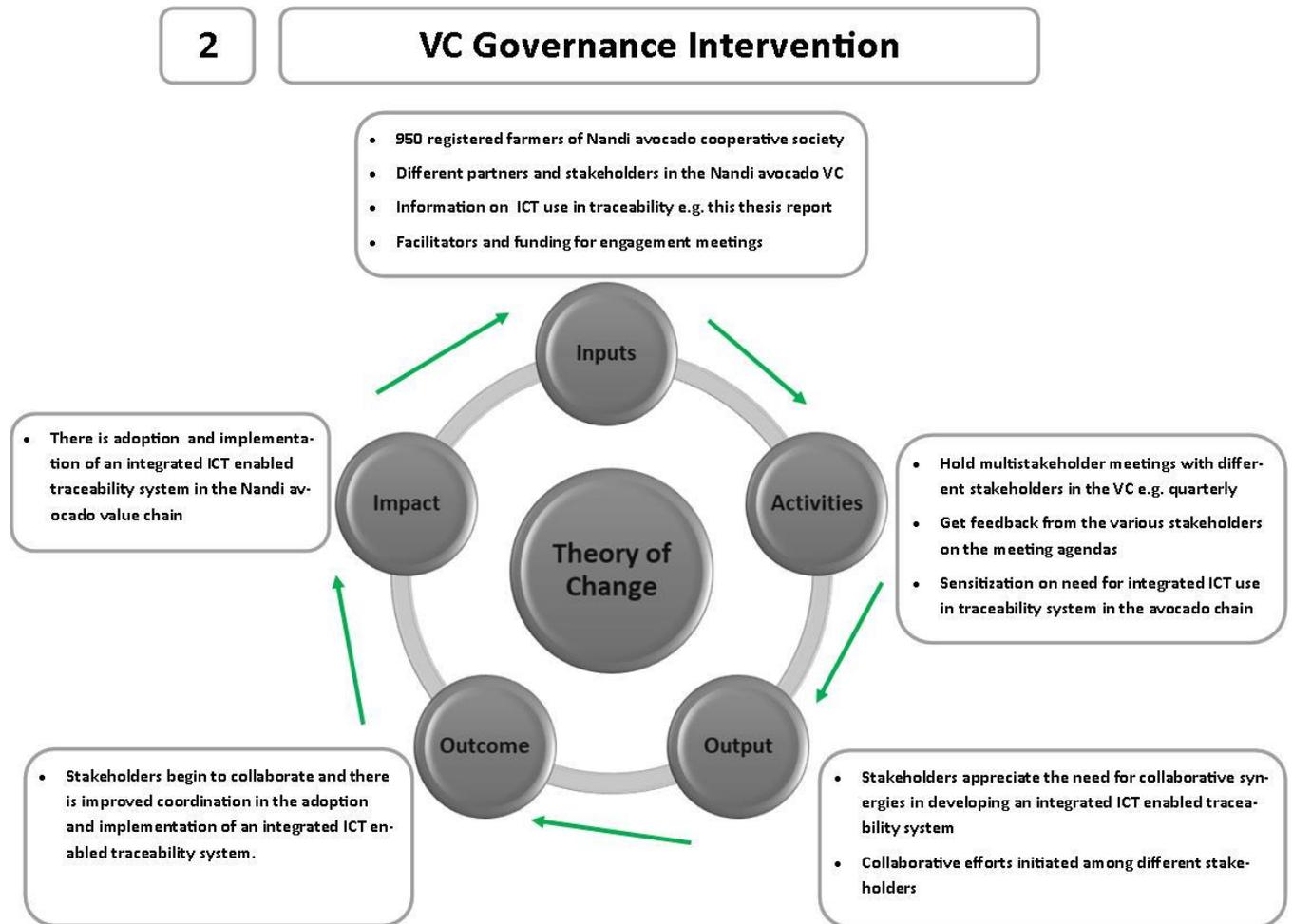
Figure 29: Technology Intervention



Source: Author's compilation

The technology intervention involves all stakeholders in the Nandi avocado chain and includes digitization of analog records kept by farmers and the cooperative society, harmonization of the existing tools/solutions used by different partners, sensitization, and inclusion of all stakeholders in the value chain and developing an integrated ICT enabled traceability system from existing and emerging technologies.

Figure 30: Value Chain Governance Intervention

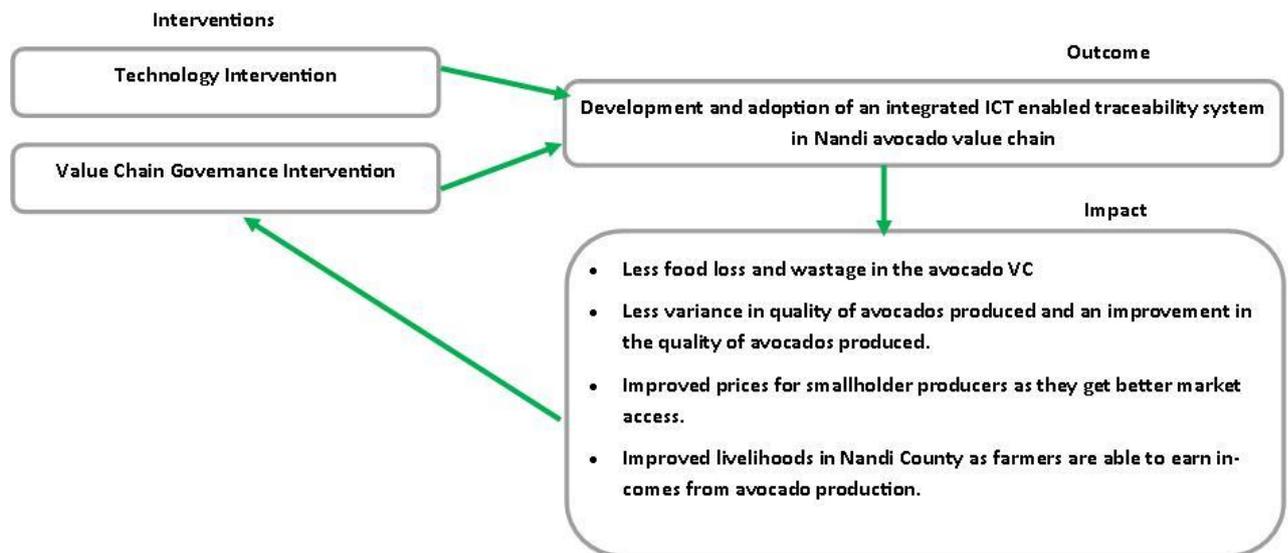


Source: Author's compilation

The value chain governance intervention involves the harmonization of the processes, functions, and information among the different stakeholders in the value chain. This is to build a coordinated and collaborative platform that is core to implementation of technological solutions developed. By leveraging on the already existing partnerships and meetings regularly scheduled, stakeholders can be engaged in a consultative and inclusive manner.

The 4<sup>th</sup> pillar of the Network Readiness Index (NRI) assesses the overall impact of ICT use in processes. From this study, specific impact (s) of an integrated ICT enabled traceability system is illustrated in Figure 31.

Figure 31: Impact of ICT enabled Traceability System



Source: Author's compilation

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

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# ANNEXES

## Annex 1 Interview checklist – County Executive (s) in Nandi County

(Researcher introduces herself and the study, reiterates the confidentiality nature of information provided and information will be used solely for the purpose of the study)

**Date of Interview** \_\_\_\_\_

**Name of Interviewee** \_\_\_\_\_

**Affiliation** \_\_\_\_\_

1. Who are the various actors/participants in the avocado value chain in Nandi County?
2. What are the other organizations that work with the participants in the avocado value chain in Nandi County?
3. How are the avocado producers organized in the value chain? E.g. Do you have large scale or small-scale producers?
4. Do avocado producers have linkages with other organizations within and outside the avocado value chain in Nandi County?
5. How does information about prices, products, production practices conveyed among the different stakeholders in the avocado value chain?
6. Where are the avocados produced in Nandi County marketed/sold? Are they sold locally or exported.
7. What is the flow of avocados from planting to being supplied into the market?

## Annex 2 Interview Checklist – ICT Experts

(Researcher introduces herself and the study, reiterates the confidentiality nature of information provided and information will be used solely for the purpose of the study)

**Date of Interview** \_\_\_\_\_

**Name of Interviewee** \_\_\_\_\_

**Affiliation** \_\_\_\_\_

1. What ICT options can be used to build end to end traceability systems in the avocado chain in Nandi County?
2. What is required to model an end-to-end ICT based traceability system for the avocado value chain in Nandi County?
3. What are the ICT solutions presently being used in agriculture value chain in Kenya?
4. How will ICT based solutions improve traceability in the avocado value chain?
5. The Network Readiness Index gives the following parameters as important in gauging the preparedness in adopting ICT based solutions by organizations.
  - a. Technology (access, content, and future technologies)
  - b. Human Resources
  - c. Policy

In your opinion, what is the level of preparedness of Nandi County in adopting ICT based traceability solutions, based on these parameters?

6. If you assess gaps in level of preparedness, what can be done to address those gaps?
7. What are the trade-offs and impact in adopting ICT for traceability solutions in the avocado value chain?

## Annex 3 Interview Checklist – Producers

(Researcher introduces herself and the study, reiterates the confidentiality nature of information provided and information will be used solely for the purpose of the study)

**Date of Interview** \_\_\_\_\_

**Name of Interviewee** \_\_\_\_\_

**Affiliation** \_\_\_\_\_

1. Farming practices e.g., sourcing of seedlings, pesticide use, water source.
2. Harvesting and post-harvest practices
3. Record keeping at various stages of production. If records kept, which information is recorded?
4. Where is produce sold? Is it aggregated with other producers?
5. What other stakeholders in the value chain do they deal with.
6. How do they get information on prices, product quality, quantities, feedback from buyers?
7. Have they undergone any certification processes?
8. How do they monitor their products during production and after harvest and selling?

## Annex 4 Interview Checklist – Transporters

(Researcher introduces herself and the study, reiterates the confidentiality nature of information provided and information will be used solely for the purpose of the study)

**Date of Interview** \_\_\_\_\_

**Name of Interviewee** \_\_\_\_\_

**Affiliation** \_\_\_\_\_

1. Where they transport the produce to and from.
2. How they transport the produce.
3. How safety and hygiene standards are maintained before and during transportation.
4. Are any records kept? Which information is recorded?
5. Which value chain stakeholders they interact with.
6. How do they get information on products, prices, quantities?

## Annex 5 Interview Checklist – Traders

(Researcher introduces herself and the study, reiterates the confidentiality nature of information provided and information will be used solely for the purpose of the study)

**Date of Interview** \_\_\_\_\_

**Name of Interviewee** \_\_\_\_\_

**Affiliation** \_\_\_\_\_

1. Products stocked
2. Where do they get their supplies?
3. How do they ensure safe and hygienic produce?
4. How do they store their produce?
5. How do they handle defective produce?
6. Other value chain stakeholders they interact with.
7. How is information on produce, pricing, quality, and quantity shared with other stakeholders?
8. How are payments effected?

## Annex 6 Interview Checklist – Importers in the Netherlands

(Researcher introduces herself and the study, reiterates the confidentiality nature of information provided and information will be used solely for the purpose of the study)

**Date of Interview** \_\_\_\_\_

**Name of Interviewee** \_\_\_\_\_

**Affiliation** \_\_\_\_\_

1. Country or countries of origin of avocados
2. Quality requirements
3. Knowledge/awareness of the avocado supply chain from producer to importer.
4. Other stakeholders in the value chain they interact with
5. Knowledge of quality systems in exporting countries
6. Traceability systems in the Netherlands to ensure quality
7. Handling of produce that doesn't meet specification
8. Opinion of ICT readiness among smallholder avocado producers
9. How is information on produce, pricing, quality, and quantity shared with other stakeholders?
10. CSR initiatives with smallholder producers

## Annex 7 Interview Transcripts – ICT Experts

This includes interview transcripts from ICT Experts including:

Joris Tenhagen – Founder/CEO – Autonomous Supply Chains Solutions Providing Company

Michael Gichoga – Vice President - Information Technology

Kevin Bett – CEO – Agritech Solutions providing company

Dan Thuo – IT Manager – Avocado Exporting Company (merged with interview with the company's Business Development Manager)

## **Interview Transcript – ICT Expert – Kevin Bett**

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interviewee is Kevin Bett, CEO, Neruva Technologies Kenya. Neruva Technologies is an agritech company in Kenya utilizing technology solutions to ensure climate smart agriculture practices.**

**Interviewer:** From present findings, traceability in the avocado chain is at the exporter level, using inbuilt systems. These are only tracking the information that the various stakeholders need. How then can we leverage existing technology to build this chainwide system that is integrated and includes, especially smallholders.

**Interviewee:** One of the things that people do not understand is that traceability starts at farm level at the production system. Tracking is done on such parameters as temperature regulation, lighting, air conditioning for controlled room agriculture, and switching on and off of water pumps at intervals. All these are do not to ensure and enhance food quality and safety.

It begins with sensor technology to pick up data on things like water/air temperature, pH, dissolved oxygen in water, all to ensure the systems are running optimally and growth can be traced.

There is programming for automation and knowing when to balance systems. So this ensures traceability is from production.

There is also traceability during transportation to monitor the food safety and quality and ensure products are not damaged. Partnerships with other companies can utilize sensor technology to monitor in real time the produce being transported and avoid wastage. Food production in Africa is done away from urban areas and traceability during transportation addresses the issue of a broken system in monitoring.

**Interviewer:** What would an ideal traceability system look like?

**Interviewee:** That would be a system that begins at production to the end of the chain and not one that begins at a random point in the value chain.

**Interviewer:** You mention partnerships, which is actually one of the components of the network readiness index in assessing how ready the Nandi avocado value chain is in adopting ICT in traceability. How can these be implemented?

**Interviewee:** There needs to be an integrated system. Each food production company could have its own open-source program that guarantees food safety to customers through Blockchain and IoT. This kind of integration requires partnerships e.g. in cloud-based service providers like Amazon Web, Oracle Cloud, and government liaison. This will allow all stakeholders, farmers, and companies to collect, access, control and present information to buyers and other stakeholders in real time. A blockchain or IoT platform is accessed by all stakeholders.

The Key also is to have regulation so that only food presented and represented in the system is traded. E.g. a supermarket selling food on an open-source platform should be able to see traceability from planting to when selling in its stores.

**Interviewer:** What is the significance of using an open-source platform?

Interviewee: It allows for transparency, access to all stakeholders and ensures costs especially for IoT technology is cheaper and therefore can be accessed by the smallholder farmers.

Most times, farmers will not adopt such technologies because they lack the information on such things as printed circuit boards, hardware and software development and transferring data to phones say through Apps. If these are made accessible, then we will have more farmers adopting.

With partnerships, it is easy to move into traceability systems e.g. Walmart partnering with IBM and Amazon Web to develop their own Blockchain based traceability system. In Kenya, we do not need to start from scratch; we can use existing open software systems and then embed and customize them as needed.

**Interviewer:** What then, would be the role of the Cooperative in implementing this system and smallholder level?

Interviewee: Cooperatives are crucial especially for farmers doing farming as a primary source of earning a livelihood. In the private sector in Kenya, Cooperative Bank has an excellent value proposition to be actively involved as they work with farmers, cooperatives and have the funding required.

**Interviewer:** What about partnerships with importers?

Interviewee: With partnerships with private sector players like Cooperative Bank, there is the real potential to advance relevant SDGs even as they collaborate with other stakeholders. An ideal step by step process would be:

Access to cooperatives and farmers, identify and open-source platform, partnering with ICT companies and farmers as part of their CSR, ensure recognition of the open-source systems and then develop plug and play IoT system for farmers that is simple to use and understand and cheap and affordable.

The upside is we have cloud-based service providers like Oracle and Microsoft that are partnering with startup and offering free cloud computing credits. They provide up to \$10,000 in free cloud credits as long as the initiative are linked strongly to SDGs. Their value proposition is in advancing the SDGs.

So we do have what we need, we just need to get all hands onboard.

**Interviewer:** Define Open Source for me in your own words.

Interviewee: Let me give examples e.g. SketchUp and AUTOCAD. These are software available to create models. SketchUp is free and requires no subscription, but AUTOCAD requires a small fee. Basically open source is one that is available to all and can be used by different stakeholders. It contains concise code that can be tweaked to address a particular need. A closed source on the other hand cannot be tweaked.

For example, if we need a messaging platform, we can look on GitHub, pick one that suits our needs and then customize it. The advantage of open source is that it cuts down on development costs and time and it has already been debugged.

**Interviewer:** If we are to develop a farm to fork traceability system for the avocado chain and ensure we are including smallholder farmers, what would we need to do?

Interviewee: Partner with private sector, cooperatives, and a bank like cooperative bank. We also need collaboration with cloud-based operators e.g. Oracle. We would also need hardware so that we are able to develop plug and play solutions. Then we hire more developers and identify hardware that is easy to customize. The key here is in building strong partnerships and collaborations.

**Interviewer:** To make it clear, please define what is meant by plug and play.

Interviewee: It means ready to go. Picture yourself buying a car and then having to buy an engine, chairs, doors, etc. differently and then assembling them yourself. So a plug and play is like a car. It comes ready to use. This is the system we need for farmers, which is easy to use.

Things like sensors need to be part of the hardware so they are customized already for specific functions.

Farmers hear terms like IoT and Blockchain and checkout. We need to simplify the process.

Regulation will also play a significant role in pricing of IoT devices, so they are affordable. They can also be mandated like the recently mandated ETR system for traders by KRA that links all transactions to the KRA portal.

**Interviewer:** How do we address the regulatory hurdles?

Interviewee: Having regulations is actually an advantage. The country that will win in the right regulations concerning the avocado value chain and very quickly and adopt traceability and ICT systems, this is the country that will win this war. Currently, we are winning the small battles by being top exporter in Africa. The real war is in being able to adopt such an ecosystem that promotes safe food for all, and at all times.

**Interviewer:** What about the spill over into the domestic market, since not all avocados produced in Nandi are for export.

Interviewee: The immediate impact will be on the large supermarkets, hotels, and traders e.g. Naivas. Farmer groups that also sell in bulk will immediately adopt these systems. Large farmers will also adopt this, and then we will see gradual adoption by other stakeholders.

**Interviewer:** How then, do we find a way of putting all these together, while ensuring proprietary information remains with the different stakeholders?

Interviewee: Data is the new oil. The future of food is traceability and production that is addressing not just addressing profits, but concerned with improving livelihoods, food safety and concern for the environment. Such a traceability system needs to address these components.

## **Interview Transcript – ICT Expert – Michael Gichoga**

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interviewee is Michael Gichoga, Vice President of IT, for an organization in the USA.**

**Interviewer: The present situation is that traceability in the Nandi Value Chain is at the exporters level. How can we use ICT to create an integrated traceability system?**

Interviewee: Importers and exporters are obviously more tech enabled than other stakeholders in the value chain.

**Interviewer: Yes. It needs to be linked. So how do we link all this according to the Network Readiness Index to address the fragmentation and different data at different levels among different stakeholders in the value chain?**

Interviewee: Working as the VP of IT with operations in Kansas, Oklahoma, Nebraska, and Texas, I can tell you that technology can be used anywhere.

I am not in the agriculture field, but technology is technology, anywhere. Technology is just an overlay in company functions. Every company in 2022 has to leverage some technology in some ways e.g. in email, text messaging and GPS. But when technology is used wrongly, it can be an overhead for the people using it.

I find that when I have failed when using technology, it is when I have started with a technology solution and then modified the problem or issued to be solved to fit into the technology. It should be the other way round. Define the problem, then find a technology solution to address that problem.

I like your project and even though it is complex and there are many players involved, when everyone starts singing in harmony it is going to be a beautiful thing to see.

No 1 product is able to address everything.

This is why using the modular approach, start breaking it down in layers at different levels of operations and then at each of these levels and layers, players are allowed to define and innovate in how they define their challenges and solutions. But there needs to be common language so that similar information is exchanged.

The value isn't in the technology itself. The technology is just a tool. The real value is going to be in the rich data exchanged between the different stakeholders and in the same format. People will not care whether it's blockchain, or IoT or AI. The value is in the data collected and shared.

**Interviewer: When we speak about similar data, this is something that blockchain can help synchronize?**

Interviewee: Correct.

Not assigning one central clearing house in blockchain leads to transparency because data is validated by different players in the chain. Some information can remain private e.g. prices between buyers and seller. All that is needed is that the data is validated. Blockchain only works if data can be validated, and a choice can be made about which data remains public or private.

**Interviewer: So how do we manage proprietary information among stakeholders?**

Interviewee: We assign attributes to a transaction and for a transaction to be valid all conditions must be met e.g. if we agree I sell you a product at \$10, then the transaction remains invalid until all of us agree to that price in the system. Once we agree, then the transaction becomes valid. Other stakeholders don't need to know what price was paid; they just need to know that the minimum conditions have been met to validate the transaction. Then other parameters e.g. volumes can be validated in the chain.

Multiple transactions can make up and aggregate transaction in the chain.

**Interviewer: Is this possible in an App?**

Interviewee: Yes, because blockchain is just a tool. The App is the interface to the tool. For example, by using blockchain you can see the different layers in the chain and transactions and at the end you are just building trust.

**Interviewer: Trust is really core, in addition to technology.**

Interviewee: With blockchain being just a tool, stakeholders don't really care about it when things work. At the end of it all, its adopting and trusting and not the tech jargon. Blockchain is just introduction value and is not the core. In the technology architecture, it is just needed to validate transactions.

**Interviewer: How then do we ensure smallholders are included?**

Interviewee: Proliferation of smart devices in Kenya is a big plus compared to say 20 years ago. Connectivity is important and the challenge would be in the data model of buying data in bundles which is expensive. I hope we will someday have a model like Elon Musk's Star link, one you have data, you should have continuous access.

Being a data rich solution, reliable connectivity must be assured. Leasing of devices can be done so farmers are able to get smart devices. However, connectivity is beyond your scope, and this has to be done at policy level in the country.

**Interviewer: In Nandi County, farmers are working in the cooperative model. How impactful is this in traceability?**

Interviewee: The thing I like about data and technology is once you have data, it doesn't need to campaign or lobby. It speaks for itself.

Once you have data, you know what works and what doesn't work. E.g. if a farmer is doing something right and having their avocados making their way to restaurants and Amsterdam, their data will speak for itself. It enumerates what works and what doesn't work. Data gives a reference point and points of correction.

For the cooperative all this data from farmers will help them not poke in the dark.

**Interviewer: What then, do we need to have an ICT enabled, chainwide traceability system?**

Interviewee: A few things:

- Connectivity that is available and reliable
- The solution has to be simple and adoptable by farmers, with a good user interface and even translated into the local languages.

- A reliable App and user interface and then figure out how distribute it e.g. part can be hosted in Kenya and part in the Netherlands. And we don't have to start from scratch, we can use already inbuilt solutions and customize them.
- Reliable devices for farmers: through CSR and philanthropic efforts organizations can partner with the farmers in providing these.
- Scalable application that is distributed so that data can "talk to each other" and more available.
- Cloud computing in hosting to allow for quick sharing of data. E.g. the banking apps on our phones, don't store data on the phones. They collect data and send it to an interface that either a server or cloud. And Cloud solutions are already available e.g. Microsoft Azure and Google Compute.

## **Interview Transcript – ICT Expert – Joris Tenhagen**

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interviewee Joris Tenhagen, Founder of PharoX Netherlands, a Smart logistics solutions provider.**

**Interviewer: The present situation is that there is little to no traceability at the farmer's level. Where it exists, it is analog on paper records kept by the farmers and the cooperative. Because of certification standards exporters have traceability systems, tracing the information they need, but not integrated with other stakeholders. They only trace the information they require. How then can we use technology in traceability and ensure the system includes everyone and especially the smallholders?**

Interviewee: Are farmers producing different grades?

**Interviewer: Yes. Hass, Fuerte and the traditional varieties.**

Interviewee: Farmers producing different grades and types means there needs to be contracts with these farmers for supply of these different grades. Technology will make it easier for farmers for uniformity and consolidation of produce. There can be time stamps for when the produce is collected. Volumes can be validated between retailers and the cooperatives, and then to the next levels. This consolidated data can then be used in the next steps in the value chain. Data has to start from the beginning in a synchronized and uniform way. That's why I am already thinking of technology like Blockchain, but maybe it's not needed. This information is used and channeled to all stakeholders from the cooperative onwards and maybe at multiple consolidation points like the packhouse or warehouse.

For farmers, it would be better if traceability is digitized because it makes life easier. Then for the cooperative it would be easier because at the push of a button, they can get better insights in different information and trends and then move on to the next steps in the chain.

IoT can be used to monitor quality of the cold chain throughout the value chain.

**Interviewer: Because traceability ends with the exporter and there is not really traceability in avocados not going to the export chain e.g. avocados are transported in public transportation, in baskets etc. What is the role of IoT in this process?**

Interviewee: It really depends on the volume because it is not logical to monitor every single box. The cooperative and farmers together with the exporters can decide on a randomized batch tracking and pick at which volumes and batches tracking will be interesting. E.g. track by grade or other differentiator by use of devices like temperature loggers. These can be single use sensors or can be reused. We try to utilize the re-usable sensors. Even if it comes back once a year, it's good enough instead of just throwing away. So we can start from a consolidation point like the cooperatives and create a reusability loop.

Farmers can record data using their mobile phones. Antennas at different points in the chain e.g. at the cooperative, packhouse can be used to track, and record information such as temperature from the farmer to the cooperative and then on to the next point.

Farmers will be able to monitor if something goes wrong along the chain, it can be traced back to the farmer. Sensors can also be used in the ripening process. But it's important to have data from the farmers.

**Interviewer: This is a customized solution for this value chain, can it be scaled to other value chains?**

Interviewee: Use of mobile phones would be the easiest way to make customized solutions for the value chain. This can then be used on other value chains e.g. different products can be selected through a drop-down menu, pictures can be added to validate products and the systems is built to recognize different products using computer vision on mobile phones.

The main benefit is that there is no paperwork or retyping, and this eliminates typos and errors. The information tells a story and is in a cycle.

**Interviewer: From the concept level, how then do we combine blockchain, IoT etc. and ensure we include all stakeholders. Some understand traceability and there are new ones who need a bit more hand holding. How do we find common ground, so we don't exclude some stakeholders?**

Interviewee: We design something very simple. The solution can be done in steps. Very small steps. Everyone needs to understand the minimum information required for the systems that has to be fulfilled, documents required and a simple standard that fulfills everything.

Then discuss with each stakeholder because each stakeholder has different roles. If new ones are understanding the system quickly, then you know you are on the right track. The you build on to the next level and add more steps if needed. Make it simple. Everyone in the value chain has their own roles and responsibilities and expertise e.g. for the farmers, it is to produce avocados and for quality control. The minimum requirements for farmers for quality and at different steps in the value chain, and then we keep doing this along each level in the value chain until we get it right.

**Interviewer: You don't want to overwhelm people and tell them this is blockchain or IoT, because then, they are not receptive.**

Interviewee: No. Just make it simple for all the stakeholders.

**Interviewer: In a perfect world, what would we need to build an ICT enabled, integrated chainwide traceability system in Nandi County?**

Interviewee: Most important is the availability of mobile network and its penetration. The network also has to be reliable. Then we do a baseline on how connectivity elements score along the chain e.g. find the smartphone penetration.

**Interviewer: Mobile penetration is quite high because of MPESA payment services so that already gives an enabling environment for a tech enabled solution.**

**What would be role of cooperatives in this?**

Interviewee: Cooperatives will aid in tracking of data from harvest e.g. quality, quantity, time of harvest etc. Photos can be used and for any discrepancies especially those with financial impact to farmers it can be verified. Attributes are immutable and this is why I am thinking of blockchain use at different levels. Discrepancies at the next stages will then need to be explained.

**Interviewer: So if something happened, say I give you Grade A at harvest, but at the packhouse I am told its Grade D, then the discrepancies must be accounted for and where they happened along the chain.**

Interviewee: Data e.g. on temperature, can be used to explain the logic in discrepancies in quality at different points in the VC.

**Interviewer: How about Kenyan avocados that are being rejected because they are harvested before they are mature. Are we able to develop solutions to detect that?**

Interviewee: I have to think about that. Maybe solutions can be for batch by batch and selection randomly. But that is after harvest, and it can be traced down along the chain.

## Annex 8 Interview Transcripts Traders

### Interview Transcript – Retailer 1

**Researcher introduces herself and the study, reiterates the confidentiality nature of information provided and information will be used solely for the purpose of the study. This interview was conducted with a retailer with a fruits and vegetables stall at Kapsabet Town.**

**Interviewer:** What products do you stock and sell.

Interviewee: I sell fruits and vegetables. Various varieties, depending on what is in season and what the customers are asking for. But I always stock the usual fruits and vegetables like sukuma wiki, traditional vegetables, tomatoes, onions, and fruits like oranges, mangoes, and avocados.

**Interviewer:** Where do you buy your avocados?

Interviewee: I get avocados from Kisii, Webuye and Nandi. I get from wherever the supplies are available. My customers do not really mind where avocados come from as long as they are fresh. But they usually like buying avocados from Nandi County so that they promote the farmers from here.

**Interviewer:** Specifically to avocados, how do you ensure you get excellent quality?

Interviewee: I have been selling fruits and vegetables for a long time, so I work with the same suppliers, so I am sure I get good quality produce. When I need to get from a new supplier, I purchase only small amounts in the beginning to make sure the quality is good and consistent. For avocados, I do not buy ripe fruits. I buy when they are still unripe, so that I ripen them in batches to sell. If they all get ripe at the same time, it will lead to losses if I cannot sell them all.

**Interviewer:** How do you store your avocados?

Interviewee: For the avocados I want to ripen, I store them in baskets in a warm place until they are ripe. For the avocados I do not want to ripen, I keep them in a cool dark room. We have some storage spaces we pay for that are near the market so that is where I keep my avocados. But usually, I do not buy in bulk, so I do not have to keep them for very long.

**Interviewer:** What do you do with the avocados that are defective?

Interviewee: If the avocados are bad, I just throw them away and the waste is collected by the County. There is nothing I can do with the damaged fruits.

**Interviewer:** Apart from your suppliers and customers, who else do you interact with in the business?

Interviewee: They County (Government) because I have to pay for my permit, the transporters, my customers of course and other traders. Because sometimes when you do not have enough produce to sell, you can get some from them. I also bank my money with Equity, so I am able to get loans from them.

**Interviewer:** Among all these stakeholders you interact with, how do you share information on price, quality and quantity required?

Interviewee: I will call my supplier and place my order. I also use WhatsApp when I need to send pictures of the exact type and size I need.

**Interviewer:** How do you receive and make payments?

Interviewee: I have a Till Number (for MPESA) because nowadays most people prefer to send money using their phones. It also helps when I am making payments because most times the supplier only sends his workers, then I directly pay the supplier using Mpesa. But some people still prefer to use cash, so I also accept cash. But even when I am paid in cash, I will deposit into my MPESA, so I am able to send to my bank account.

## **Interview Transcript – Retailer 2**

**Researcher introduces herself and the study, reiterates the confidentiality nature of information provided and information will be used solely for the purpose of the study. This interview was conducted with a retailer hawking avocados in Kapsabet.**

**Interviewer:** What products do you stock and sell.

Interviewee: I sell avocados in Kapsabet Town, mostly around the stage (bus stage) because that is where there are many customers.

**Interviewer:** Where do you buy your avocados?

Interviewee: I buy my avocados from the farms and especially the quality that is not bought by the larger customers. When avocados in Nandi are not in season, I buy from the wholesalers in the market. They get their avocados also from Kisii and Webuye.

**Interviewer:** Specifically to avocados, how do you ensure you get excellent quality?

Interviewee: I visually check each avocado I buy to ensure it is not defective. Because I buy a small quantity each day, there is little risk of buying bad quality avocados. I buy the avocados that are ripe and ready to eat because most customers purchase to eat immediately.

**Interviewer:** How do you store your avocados?

Interviewee: I do not store avocados because I only buy the quantity I need for the day. If at the end of the day I have some still left, I will go home with them and add them to my purchase the next day.

**Interviewer:** How many avocados do you sell on average daily.

Interviewee: It really fluctuates daily. But on average, on a good day, I can sell 100 fruits at between Ksh. 20 to 30 per fruit depending on the size. So it's not a bad business. Sometimes sales can be low, but that is the nature of business.

**Interviewer:** What do you do with the avocados that are defective?

Interviewee: I do not buy bad avocados, but if I see they are getting riper and I still have a lot to sell, I reduce the price so that I sell faster. If business is really slow, sometimes I will take some avocados home to be consumed by my family instead of them going bad.

**Interviewer:** Apart from your suppliers and customers, who else do you interact with in the business?

Interviewee: No one else really, because I keep my money in KCB Mobi, so I do not even need to go to the bank. At the end of the day, I just transfer what I have sold to my mobile money KCB account.

**Interviewer:** Among all these stakeholders you interact with, how do you share information on price, quality and quantity required?

Interviewee: I usually buy the avocado myself, so I just go to the market and purchase. We also communicate on the phone using text message.

**Interviewer:** How do you receive and make payments?

Interviewee: I use cash and MPESA.

### **Interview Transcript – Retailer 3**

**Researcher introduces herself and the study, reiterates the confidentiality nature of information provided and information will be used solely for the purpose of the study. This interview was conducted with a retailer selling fruits and vegetables as well as running a small “kiosk”**

**Interviewer:** What products do you stock and sell.

Interviewee: I have a small shop as you can see. I sell the normal household goods like sugar, bread, milk. At the front of the shop I have a small section where I sell fruits and vegetables. I also buy commodities like oil in large quantities and sell them in smaller quantities. I also sell charcoal and firewood. So really, I sell many things that people need in their homes, but in small quantities.

**Interviewer:** Where do you buy your avocados?

Interviewee: From Kisii and also from around here in Nandi. There are lorries that pass by here from Kisii on the way to Eldoret to sell avocados, bananas, and sugarcane, so I buy from them. I also buy avocados from the farms here in Nandi when they are available.

**Interviewer:** Specifically to avocados, how do you ensure you get excellent quality?

Interviewee: Firstly, I make sure I buy different varieties like Hass, Fuerte and the traditional varieties. This is because different customers want different types. The traditional types from Kisii and Nandi are larger and have a smoother texture. Many people like that type. I carefully pick the amount I pick from the sellers because I do not want losses. The sellers are generally selling us good quality avocados because they also buy only the good quality from the farms.

**Interviewer:** How do you store your avocados?

Interviewee: I keep them in the space at the back in my shop. I store them in baskets and cover them well in batches, so they do not all ripen at the same time.

**Interviewer:** What do you do with the avocados that are defective?

Interviewee: Avocados will usually go bad if they ripen quickly and at the same time and I cannot sell them all. When I see that beginning to happen, I will reduce the price, so they sell quicker. For the ones that go back, I take them to my farm and add to my composting site with manure from my animals. It makes very good fertilizer. So nothing is really a waste. I use the manure to plant these vegetables I see here.

**Interviewer:** Among all these stakeholders you interact with, how do you share information on price, quality and quantity required?

Interviewee: Mostly using WhatsApp. Everybody is using WhatsApp now. Everything is communicated on the phone because we are all not in the same place. Some of my customers will make an order on the phone and I will send to them using boda-boda (motorcycle riders).

**Interviewer:** How do you receive and make payments?

Interviewee: Most of the times I use MPESA. But I do not accept cash to my number. You cannot trust some people, especially the ones who are not your regular customers. They will make a payment to you phone and the reverse the payment! I have a Till Number (for MPESA), so that the payments go direct to my bank account. This regular banking also helps me build a credit history with the bank, so I am able to take small loans. But some people also prefer to pay using cash.

## Annex 9 Interview Transcript – Exporter Avodemia Kenya Ltd

### Interview Transcript – Avodemia - Avocado Processor and Exporter

**Researcher introduces herself and the study, reiterates the confidentiality nature of information provided and information will be used solely for the purpose of the study. This interview was conducted with Jack Njoroge – Business Development Manager and Danson Thuo - Head of IT**

#### **Part 1 – With Business Development Manager**

**Interviewer:** How does your company conduct its operations?

Interviewee: We work with 4700 contracted farmers. 250 of these farmers are certified both in GlobalGap and Organic, which is an expensive process. Our farmers are presently located in Kiambu, Murang'a, Meru and Subukia. We are also in the process of expanding into more areas like Eldoret (Uasin Gishu County) and Nandi County.

**Interviewer:** How do you trace and track the avocados you receive from the different farmers?

Interviewee: We use an Intersoft system that tracks the avocados right from harvesting. We use weighting gargets to weigh the avocados from different farmers, so we know what we got from each farmer. We pay the farmers after harvesting. We use a GRN (Good received note) in our system so the farmer also has a copy.

Organic avocados are collected in green crates and the conventional avocados are collected and packed in red crates. We also follow the required phytosanitary procedures when binning and putting in batches. Consolidated batches for farmers are then tracked. Each shipment contains 4 batches.

For organic avocados, we also include a certificate of inspection. For the conventional avocados through brokers, there are common batches that trace back to the farmer. They include the name of the supplier. Visual inspection is also done.

**Interviewer:** What certifications does Avodemia possess?

Interviewee: GlobalGap, BRC, HACCP, ISO 9001, USDA Organic

**Interviewer:** Where do you export to?

Interviewee: Our biggest markets are the UK and Spain, both for the fresh avocados and cold pressed avocado oil.

**Interviewer:** What prices do farmers get?

Interviewee: Prices fluctuate, but generally, it's Ksh100/kg for the organic avocados and Ksh. 70/kg for the conventional avocados. Selling price is determined by prevailing global market rates. Besides the prices, we want to ensure we are meeting the client specification at harvest. These include a dry matter content of between 21-24%.

**Interviewer:** How does your traceability operate?

Interviewee: It is an inbuilt, inhouse system which ensures we are tracing our avocados from the farmers to when we sell to the market. Payments are also tracked in this system. Traceability is difficult to implement especially when you talk about an integrated system. This is because it is expensive and some information e.g. prices is confidential only between some parties e.g. the exporter and importer.

**Interviewer:** What then would it take to build an integrated traceability system along the entire value chain?

Interviewee: Certification is key to developing such a system because then it means all the stakeholders are being subjected to the same standards. Certifications are key to transparency in the value chain. For example, all players have to adhere to the same GAP like IPM. That way traceability will be for a similar product.

**Interviewer:** You manage both the fresh avocado line, and you also process avocado oil. Would you elaborate on that.

Interviewee: Our fresh line is the priority and processing is done on avocados that do not meet export quality. This avoids a loss to the farmers. We process cold pressed avocado oil.

**Interviewer:** How do you ensure avocados are meeting the required quality?

Interviewee: We only work with contract farmers who work together with our agronomists and field officers. They get training on GAP and import requirements. When the avocados get to our facilities, there is a quality check at sorting and packing. Our farmers also understand the quality requirements needed as they get training on market requirements. We also have the farmers segregated in zones. A week before harvesting in a particular zone, we will do sampling to make sure the avocados are ready for harvesting.

**Interviewer:** How do you manage the waste from processing?

Interviewee: Because the oil is made from the pulp. The skin and seeds are sold to a company called Eco-Dudu. They process these as a protein substitute for chicken feed.

**Interviewer:** What is your current business strategy?

Interviewee: We would like to expand into more export markets and also venture into other chains besides avocados.

We also want to keep improving our quality control, by ensuring our farmers are trained and certified. Most farmers are now knowledgeable on certifications because they know it is the only way they will access export markets.

We would also like to form more partnerships with importers so that we are able to include more farmers. If farmers are in groups, it will be easier for the exporter to bear the cost of certification.

Our plan is also to shift from conventional avocados to organic avocados because ultimately, they have a lower cost of production, and their demand is higher.

## **Part 2 – with ICT Manager**

**Interviewer:** What ICT systems do you use at Avodemia?

Interviewee: We have a SAP/ERP system. These are systems we use for finance, HR and all other functions including traceability of the avocados. The ERP system is customized so that we have traceability from farm to dispatch.

**Interviewer:** Is it a specific system?

Interviewee: It's the Avodemia System and all I can tell you is that it utilizes Blockchain and IoT.

## Annex 10 Interview Transcript Seedling Supplier

### Interview Transcript – Seedling Supplier

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interview was conducted with the Farm Manager of a mixed farm (avocados, pineapples, and also avocado seedling supplier. It was carried out in Kiswahili**

**Interviewer:** What varieties of seedlings do you plant?

Interviewee: All kinds. Hass, Fuerte and the local varieties. But the most popular is Hass because it's the variety that has most demand. It's the one the buyers look for.

**Interviewer:** Are your buyers only from Nandi County?

Interviewee: No. We have buyers from Nandi County but also from places like Eldoret and Vihiga. So we sell to anyone who wants to buy the seedlings.

**Interviewer:** Where do you get the seed for planting?

Interviewee: We get the seed from Eldoret and Kakamega. We usually don't know the variety of the avocado we are getting, and we only find out after the seedling grows. We only know the variety when we do our own grafting.

**Interviewer:** How much do you sell each seedling for?

Interviewee: Each seedling is Ksh. 150 and most buyers get over 100 seedlings. We plant throughout the year so that the seedlings are available all year round.

**Interviewer:** How do you market your services?

Interviewee: I belong to the cooperative (Nandi), so marketing is done through the cooperative. Members are always aware, and they also tell other non-members about our nursery.

**Interviewer:** Besides selling the seedlings, do you offer any other services to the buyers?

Interviewee: Yes. We also give a little training to the buyers because most of them are planting avocados for the 1<sup>st</sup> time. So we educate them on how to plant the avocados e.g. how to dig the holes and use organic manure and also about spacing.

**Interviewer:** What is the spacing you advise the buyers?

Interviewee: We used to do 9 by 9 (meters) but now we are advising them to plant the seedlings at 7 by 7 (meters). This is the best spacing for the avocado trees.

**Interviewer:** After the buyers get the seedlings, do you have any follow up with them.

Interviewee: Right now, we don't follow up. But if the buyers have any issues, they will call us, and we will try and resolve the issue. E.g. we can replace some seedlings for them.

**Interviewer:** Are the seedlings you sell to farmers certified?

Interviewee: No they are not, but they are very good quality.

## Annex 11 Interview Transcripts Farmers

### Interview Transcript – Producer and Cooperative Official – Chief Paul Tirop

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interviewee is Chief Paul Tirop, an avocado producer and marketing coordinator at Nandi Avocado Cooperative Society.**

#### **Interviewer: Please tell me more about the operations of the cooperative?**

Interviewee: I am a producer myself and in the cooperative, I oversee both marketing and production. The avocado chain in Nandi County is young, but very promising. The biggest issue we have to address is market access, because farmers want to know that when they produce, there is market for their fruits. Right now we have 2 main exporters that work with our farmers, Sunripe and KEITT. Because of the competition among them, we are seeing farmers get better prices for their avocados.

#### **Interviewer: How do you manage the production and marketing functions?**

Interviewee: Nandi County has 6 wards, so we have zoned 3 wards each for each exporter and buyer. Sunripe buys only the export quality grade, but KEITT is buying all the fruits – Hass for export and Fuerte for Oil processing. However even with this, we still have some challenges.

#### **Interviewer: What are some of the challenges you are facing in the value chain?**

Interviewee: Hailstorms sometimes destroy the avocado trees, but we are trying to help farmers by providing nets to protect the trees from hailstorms. We also need more extension services to the farmers, so they are able to produce more export quality fruits. This also includes training and knowledge on production processes, so the farmers are doing the right thing from the start. WE also have pest and diseases that sometimes damage the fruits.

#### **Interviewer: What are some of the things you are doing to address these challenges?**

Interviewee: We have partnerships with stakeholders e.g. the exporters and we are also seeking more partnerships in providing nets to cover the trees. Nandi is a good ecological zone for producing avocados and have great potential to produce avocados year-round if these challenges are addressed. Because our production is rain fed, we may need to do irrigation during the offseason. We look to find ways to empower our farmers economically.

We also have plans to have a packhouse for value addition so that all our fruits are marketed, either for export or other uses.

We can make products from the seeds and husks e.g. for animal feeds so that the entire fruit is used and doesn't go to waste.

Our major plan is value addition through the packhouse because we want to market all our fruits by sorting, packing, and exporting. There are also some by products e.g. when we make oils, we shall produce animal feeds from the seed itself and the husk. That is our major plan for marketing so that nothing goes to waste. Even the rejected avocados will earn income, and this will make the farmers enjoy being in the value chain even more.

For our avocados, we are mostly using organic manure which leads to less costs for inputs.

However we need to collaborate more with the Ministry of Agriculture and other stakeholders to strengthen the chain.

**Interviewer: So how do you ensure you are producing quality fruits that are meeting market requirements?**

Interviewee: Our goal is to have the buyers know the source of the avocado so that they enjoy the fruits from Nandi County. We keep records on paper up to the packhouse, but these need to be digitized.

**Interviewer: What is your 5-year plan for the cooperative?**

Interviewee: We want to build more and stronger partnerships so that we are able to have farmers trained on the same thing and even certified. We also need exposure for the farmers e.g. field tours so they can learn what is working elsewhere. We also need resources and financial support especially in implementing the packhouse.

**Interview Transcript – Nandi Avocado Cooperative Chairman and Producer – Marcellinus Serem**

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interviewee is Marcellinus Serem, a producer, and Chairman at Nandi Avocado Cooperative Society.**

**Interviewer: Please tell me more about the operations of the cooperative?**

Interviewee: We were assisted by the Nandi County Government to begin the cooperative, which is now 4 years old. This brought avocado farmers together.

Our main objective is marketing of the avocados produced because the major problem is market access. Avocado is green gold. Even with the few harvests, we have experienced lots of value. It has assisted homesteads and families. School fees is being paid and there is also other assistance from the avocado. We want to see increased member registrations in the next 3 years.

We also project to increase production land to about 10,000 acres which will yield about 800,000 to 1 million trees if we assume about 80 trees per acre. And assuming about 200 fruits per tree that is a lot of income about 200 million Kenya Shillings.

**Interviewer: What plans have you put in place to realize this?**

Interviewee: Nandi is projected to be one of the best places for avocado production due to its ecological aspects. There is need for a packhouse. However, due to managerial problems, we still don't have a packhouse due to for example over-projection of the income required to build the pack house. In the North and South Rift, there is no pack house for fruits and vegetables. There are only pack houses for flowers.

We have acquired land for the packhouse, done a feasibility study, we have the architectural drawings, but we are lacking the funding. There is a lot of need for value addition even at the Ward levels in terms of cottage industries to prevent waste. We also need to find a way of utilizing the Eldoret International Airport.

We need to find a way of linking shelf price to farmgate prices. The fruits are fetching good prices, but these are not trickling down to the farmers because of how the value chain is structured. The exporters dictate the price the farmers get. If the farmgate prices can be increased so that farmers are getting 60% of shelf prices, that would really help farmers.

We also need partnerships. But you know even in other chain like dairy where there are partnerships, the issue is prices. The cooperative needs assistance to be able to directly export and for this a pack house is needed that will also help in value addition. There is also the need for certified seedlings to be used by farmers.

Nandi County is often mistaken for Eldoret and therefore Uasin Gishu County, so the County Government needs to do a better job marketing the County. The same way we are the source of champions for athletics, we can also be the source of avocados.

They should market the good climatic conditions in Nandi County for growing avocados. Growing avocados in Uasin Gishu County requires a higher investment than that required in Nandi because of this reason. However the prominent residents of Nandi live in Eldoret and when they welcome partners meant for Nandi, it is assumed they are doing so on behalf of Uasin Gishu County.

**Interviewer: How about the shift from tea to avocado farming?**

Interviewee: Avocado is being intercropped with tea and in fact this intercropping leads to better avocados being produced. In the Nandi Tea Estates for example, they are reducing the tea plantations as more avocado are planted..

Nandi avocado farming is now an agribusiness. People are seriously doing it as a business to assist families. Some farmers have old avocado trees even 25-40 years old but are not transforming to business as they grow the varieties needed by the market.

**Interviewer: What are some of the factors promoting avocado farming in Nandi County?**

Interviewee: There is availability of land and there is also no need for irrigation. January to March is the only time we may need to irrigate the farms. Even though Nandi County has smaller orchards compared to Uasin Gishu, there are more avocado farmers in Nandi, so there is potential for higher yields in Nandi County.

We need more direct partnerships with business partners in the Netherlands so we can learn about business practices. For example in the Netherlands, they don't really plant much, yet they are the leading exporters of everything. It's all in the technology even in the traceability you mentioned.

**Interviewer: Is there any traceability in the value chain right now?**

Interviewee: Right now, traceability ends at the pack house as avocados are mixed with others. The cards given for traceability are only for payment. The real traceability and who does the best fruit is still a nightmare and we need to find a way to reach farmers for real traceability. For example tea farmers have lot numbers and batches. E.g. a lot number for Nandi County and each farmer will aid in traceability.

With lot numbers, batch numbers and farmers contracted, soil tested, it will yield to higher prices. Batch numbers make the avocados identifiable from farm to shop.

One farmer has tried, but because of the low volumes, they have not been successful. So farmers need to come together to address traceability.

**Interviewer: Is there any data kept by farmers on production.**

Interviewee: No. But from next year, with the NARIG project, we will get trained personnel, reach out to farmers through social media and during meetings so that they start keeping production records. We also need training on managing our avocado trees e.g. pruning, using the right seedlings.

**Interviewer: What is the 10-year plan for the cooperative?**

Interviewee: We want to foster more partnerships for growth of the value chain in the County.

## **Interview Transcript – Producer and Cooperative Official – Pius Choge**

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interviewee is Pius Choge, a lead producer and official at Nandi Avocado Cooperative Society.**

**Interviewer: Please tell me more about the operations of the cooperative?**

Interviewee: The cooperative is still new, and it was formed to provide synergies to sell our produce. We are still working on the formalities so that we are able to meet standards.

**Interviewer: Nandi County is known for tea farming, why the shift to avocado?**

Interviewee: This is part of the agriculture diversification strategy by Nandi County. More and more farmers are moving away from depending only on dairy, maize that are being affected by climate change. We also have to adapt to what the market wants. Farmers have been having the traditional varieties of avocados, but we are not moving to cultivating Hass and Fuerte.

**Interviewer: How many members does the cooperative have?**

Interviewee: About 1000, but not all have planted avocados yet. They are all smallholders, all having about 1 acre each. We are not sure yet of the yield per acre, but I hear we can manage up to 1000 trees per acre. The maturity is 3-4 years. The cultivation is rain fed and we had our first export by Sunripe last year.

Avocado is an easy crop for retirees they have the land and can wait for the trees to mature. Young people have no land and because they want quick money, they don't want to wait for the trees to mature.

We are growing Hass and Fuerte varieties, but the challenge is in meeting the quality required.

**Interviewer: Speaking of challenges, what other challenges do you face?**

Interviewee: Producing the required quality and sizes required, pests and diseases and we are also trying to move away from using chemicals in production. The weather is sometimes unpredictable e.g. hailstorms that damage the trees.

**Interviewer: Are you aware of the export quality standards?**

Interviewee: We only know of sizes, and this is training done by Sunripe by using measuring bins for the different sizes of avocados. Other quality requirements? No! The rejection rates at the Sunripe pack house are high because there is not testing of avocados on the ground (in the farms). There is no training on dry matter, and we only get blanket warnings that keep fluctuating. We don't understand what dry matter is and we are only trained to look for color and that is not enough. Maybe the testing can be more inclusive if we got a tester at the cooperative.

**Interviewer: What happens to the avocados rejected by the buyers?**

Interviewee: They go back to the farmers, and some are even dumped on the roads because it's a loss.

Partnership with the exporter is needed at production level to avoid these losses.

**Interviewer: Is the production target export or the domestic market?**

Interviewee: Our target is export, but 2<sup>nd</sup> grade are sold to domestic processors for manufacture of oil and soap. The price is market driven but is averagely 70-100ksh/kg of export grade and those sold to the domestic processor are sold for Ksh 20/kg.

**Interviewer: So then, how do we develop a traceability system in the Nandi Avocado Chain?**

Interviewee: Training is required to understand the entire process from land preparation e.g. digging holes, proper composting to ensure proper root development. Training is needed from Day 1 to ensure even the right seeds are used. Traceability is needed also for reputation control and to avoid rejection. Training should also be done on proper harvest. After Sunripe harvests and picks the avocados from the farms, no traceability happens. We also need a cold room so that avocados are stored right after harvest.

**Interviewer: How about the partnerships within the value chain?**

Interviewee: We have the World Bank working through the NARIG project and they provide certified farmer groups with assistance to start certified nurseries. However, we still have copycats selling uncertified seedlings. There is need to hire knowledgeable personnel at the cooperative.

**Interviewer: How can we effect traceability within the Nandi avocado chain?**

Interviewee: First we have to understand what the market wants. Farmers can then plant enough to sell their own consignments with their own label numbers so that they know why and when they don't meet quality standards. Through the cooperative, aggregation can be done to ensure there are enough volumes and the avocados can be traced back to the cooperative.

**Interviewer: How are payments made?**

Interviewee: Payments are made through the cooperative because farmers can use them as collateral for inputs acquisition. We also want to form a SACCO so that farmers can access loans. We are currently not using MPESA for payments, only for payments of registration dues.

**Interviewer: How about partnerships with importers?**

Interviewee: We currently do not have any linkages with importers, and this is an area of partnership we are seeking. Remember "If I succeed, you succeed" that's how it works in this value chain.

We can learn a lot from the tea sector which we have a lot more expertise in e.g. the farmer is actually able to reach the end consumer. In the tea sector, all farmers are also certified. SO there's a lot we can learn from how the tea sector works.

## Annex 12 Interview Transcript Fairtrasa – Avocado Importers

### Interview Transcript – Organic Avocado Importer

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interview was conducted with the Stephan Schoemaker – Supply Manager at Fairtrasa Holland (an importer of various organic fruits from different fruits from different countries).**

**Interviewer:** For the FORQLAB project and my thesis, my focus was the ICT aspect of it and assessing the readiness of Nandi County in adopting an ICT enabled, integrated chainwide traceability system. And how we can integrate smallholders into the traceability system. From initial findings, the traceability they have in analog, on pieces of paper and in paper records are the cooperative. The traceability ends after the avocados are picked by the exporter. SO they have no way of knowing what happens after that. Further up the chain in the domestic market, we do not have formal traceability happening at those levels. The only level at which I found traceability happening is at the exporter levels. Using in built systems that do not include other stakeholders.

Interviewee: The big question, do they want to have that knowledge? We work with some smallholders, but most say lovely I know where my avocados are going, but at the end of it, all they are interested in is the money and getting paid. We have 3 tiers of farmers, from Tier 1 to 3 and tier 3 are the farmers who really want to evolve to entrepreneurship.

The other thing is this, in a place like Kenya where small holders have a few trees, traceability may be hard to implement because of the cost implication. Small volumes from few trees means there is no Global gap certification, which is expensive to obtain for individual farmers. Certification will lead to easier traceability. Due to these high costs, in most cases dealing with smallholders, we have traceability handled at the packhouses and by exporters who are able to and understand what they are doing. But people generally like a story and would like to know who the farmer is.

Complete traceability is not easy. It is a complex process and presently, we are trying out a project that is utilizing blockchain with QR codes. This is however only possible with bigger farmers. E.g. we are using this with a banana farmer in the Dominican Republic. Blockchain needs special codes and unique identifiers, and this makes it easier for bigger farmers.

In theory, everything is possible, but the key is translating this theory to practice. Theoretically, everything is possible, operationally, we call it a lot of Dutch Bears on the road, meaning there are difficulties in implementing”

Interviewer: How then can we integrate all the stakeholders in the process?

Interviewee: Many different stakeholders mean extra costs, slow down in processes and that will affect revenue. We have to analyze the feasibility of how to implement.

Interviewer: In Nandi County, we have farmers who are also in different value chain like Tea, because Nandi is a tea zone, and often there is the comparison to that value chain. Would you say there would be benefits of avocado smallholders working in cooperatives?

Interviewee: There are definite benefits of working in cooperatives: it is easier to upscale, with farmers working together there is cooperation and collaboration, it is easier to get certification due

to the larger numbers and things like inputs will be cheaper. However this adds another layer in the supply chain/

Interviewer: How so?

Interviewee: In the normal supply chain, the avocados are moving from the grower to the packhouse to exporters. However with cooperatives, another stakeholder is added so that now the avocados are moving from the grower to the cooperative, to the packhouse then to the exporter. This has costs implications. This costs implication has to be factored in to ensure revenue will not be affected.

Interviewer: How do you communicate with your smallholders in matters like pricing, quality, quantity?

Interviewee: We have our own offices are country level e.g. in Dominican Republic, Peru and these communicate directly with the farmers. We do not have an office in Kenya yet because we do not have enough verified suppliers. In the past year, we have over 40 willing suppliers from Kenya and Tanzania, all claiming to be growers, but we know how that works, they collect from different sources and this makes it hard to verify But we are doing a SWOT analysis for entry into Kenya, because Kenya is getting stronger in the avocado market. And I am talking only about organic. We are not like Satori or special fruits that do both conventional and organic avocados. We help the growers we work with because we are not going to tell them we can only take some fruits; we take all the fruits from the trees and these range in sizes from 18 to 22.

Interviewer: SO what would take for you to venture into Kenya?

Interviewee: We are doing a SWOT analysis, but you know that is not a straightforward process We do not fly organic fruits, because we do not believe organic fruits should be flown. We worked with Mavuno Organics previously, but it took 2 years to streamline the process. So the need is for reliable suppliers.

Interviewer: Would you say that your business model addresses sustainability issues?

Interviewee: Yes. Absolutely. We are not just striving to be carbon negative or positive, but to have a future proof product instead of just trading. Other initiatives include regenerative agriculture, living wage to farmers, reforestation efforts in Peru and Dominican Republic. Our focus is on reliable and trustworthy suppliers, and we focus more on quality produced and sold rather than quantity. We could supply more and make more revenue, but that is not our focus.

Interviewer: What do you do with avocados that do not meet specifications:

Interviewee: Well, two things. The first one is having avocados that have issues with customs. That is a big one can ruin the business, so we avoid that. The second one is damage to some of the fruits. In this case, we take it up with the insurance. This is why there is a need to deal with reliable suppliers who understand the specifications.

Interviewer: What is your payment model?

Interviewee: We have a 60/40 arrangement with farmers, where 60% of profits go to the farmers and 40% to Fairtrasa. We do not use a market prices, but make sure we are getting the best prices for the farmers. It also ensures responsibility in the entire supply chain because if the farmer does a good job, they get higher prices and if they do a bad job, they get lower prices. Fairtrasa takes the costs and then profits are split. This also allows for risk management in the process.

Interviewer: So what role would blockchain, IoT and AI play in the traceability process.

Interviewee: At the heart of the process is trust in the different stakeholders. Blockchain can enhance the transparency of the process, but it does not eliminate the need for trust among the different stakeholders. The bottom line for us, is more income to the growers. There needs to be a balance between business and responsibility to other stakeholders.

Interviewer: What CSR activities do you engage in?

Interviewee:

1. During Covid, we had a project where we developed a Wi-Fi point to allow for education in Peru. The project costs only 500 Euros, but the benefits were immense, and there was happiness that they could now even view Netflix 😊
2. We have planted 3000 seedlings of new trees, next year we aim to do 10,000 trees and 50,000 by 2023. This is in the Dominican Republic.
3. We built bathrooms and a self-sustaining farm in the Dominican Republic.
4. We also supplied kits in small bags for kids with materials like crayons in them. For us it is a small thing, but it makes a significant impact in the communities.

Interviewer: What impact do you want to make?

Interviewee: We want to make impact for the world, not just by greenwashing, let's call it that way, but by doing it the correct way, in a proper way. That is our corporate responsibility.

Interviewer: What would be your advice to the avocado farmers, in implementing a traceability system?

Interviewee: Work in cooperatives to split costs, gain certification and increase their bargaining power with say the exporters.

## Annex 13 Interview Transcript Airflo Logistics – Logistics Provider

### Interview Transcript – Logistics Provider - Airflo

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interview was conducted with the Peter Kristensen – Managing Director, Kenya. Airflo is a fresh produce logistics provider with offices in different countries.**

**Interviewer:** I do not know how much you know about the FORQLAB project. It is to reduce food loss and wastage. My specific focus for my thesis and also for the project is assessing the ICT readiness in adopting an integrated chainwide traceability system, so that is my specific focus and so that is what I would address with you today.

What I want to understand is how you manage your processes from production to the markets.

Interviewee: So majority of the avocados they will, they go by sea freight. So I'm not, I cannot tell you exactly how avocados are transported via sea because that typically goes straight to the shipping line. So at Airflo we are freight forwarders and 80% of what we transport is flowers.

We do have occasionally some avocado shipments by air, but most avocados will go by a sea because of simply because of the cost. Yeah. So I would, I would assume 90 plus percent of all avocados are leaving Kenya on sea freight and then on occasion I think this week we may have a couple of avocado shipments. But anyway, my comments I think they are applicable to any commodity that you ship. So what we do for flowers vegetables some herbs as well, is done for avocados.

It is quite simply data loggers like temperature loggers. Actually the methodology is the same, but it is just a matter of is it working well? Is it us that put in the data logger because we will monitor an airline or one of our suppliers performance. Or it the customer who actually does it to make sure that they can monitor the cool chain all the way from the farm.

So to give you an example, we have a customer in Australia, and they have in all their shipments. They will. They have demanded that their suppliers, they put data loggers and typically in one of the boxes because you will have if you have a shipment, you do not have a date, you cannot have a data logger in every in every box of flowers because it would be cost prohibitive.

So to give you an example of the cost, I think I think a single use temperature data logger is about. I do not know if it is relevant for you, but it is about \$25. And so then you can get some that are multi used where the battery will last for a year. And I think do not hold me too. But I think they are more than \$100 or so, so evidently.

And typically what our customers use are the single use because they the logistics of getting them whether it's Europe, Australia, anyway, else of collecting them, getting them back to the country is just it's just not viable. So it happens sometimes we do it sometimes, but we may need to use the.

The ones with the yellow battery life when it's for local purposes. So for example transporting to the airport or within the airport, then we will keep that because then it's easy to connect them back. But the single use is what most people use. They will be put in typically one or two and we also have

other flower farms that are doing it themselves. We put in a number of boxes. So if you have 100 boxes I would assume maybe three boxes or so. Now more not much more than that.

Simply because if you put in too many, you know it you the sale price of the flower cannot absorb that kind of cost if you have to \$75.

And then there are some so that they're the logs we have. There's a couple of places on route from, say, Nakuru and from Naivasha into and I think also up from Mount Kenya side there's a couple of places where there is a receiver.

So technically it needs a receiver to transmit the data, so I think there is one or two places on each route where there is a there is simply a receiver. So like a router.

**Interviewer:** How is the data transmitted?

Interviewee: To put it simple, that would receive the data and then because the logger is continuously monitoring the temperature so then you get a graph at that at that data point. When it comes into our code store we also have it so and I think the reading is you can set the reading, but I think it is every one minute or two readings, so you get multiple readings on these data loggers.

All the products delivered to a cold store. We will then do what we need to do so palletized and put them on an air freight palette or sea freight container.

And for air freight, we will then transport to the airport. We are within the airport, but to the actual ground handler, so each airline will appoint a ground handler to receive the airline palettes, put them into their cold room, and then when the aircraft arrives, they will take the airline palettes and move them to the aircraft for loading onto the aircraft and onwards. So the ground handlers, they all of them, they have a data, sorry receiver sitting in their cold storage. So the data log is also transmitting at that point in time.

And then obviously on the aircraft, you cannot see on, on, on, on the aircraft, what you are not transmitting. But then when it arrives in Amsterdam, you also have receiver sitting in most of the ground handlers. And then of course, when it reaches the customer and then they simply go online and they can download the entire sheet and then they will actually show from it was, it is a very basic graph where it shows the date and the time and then it will show the Y axis is then the temperatures.

**Interviewer:** So the data is being monitored real time?

Interviewee: Yes. And it will show a curve of how the temperature has developed over time, and you will typically see a little bit of this.

And then I mean, you know much more about this than me, but it is exponential of course, because of you and all the rest of it. So the moment the temperature starts rising is not straight, it will go like this. Yeah. So that's typically what in order simplicity what they're using to monitor temperatures. You can also get data loggers.

I am not sure if it's relevant, maybe for avocados, because I'm assuming that if avocados bounce too much around that they will not be that that consumers will not buy them because they will have dents and all the rest.

But I think I know you can get data loggers which I think is more used in the pharma industry that will also that's, so this data logger is inside the box.

But you can also get data loggers that you can put outside on a on a couple of boxes and that will actually show you if it is. If it's a very sensitive product that is inside.

That cannot be shaken now, now moved around too much. You can actually have one. And if that locker will give you, I think it's typically a color code, so it will show red for example. If that box has been moved, you know in a way it should not happen. And then the receiver can reject it and say no, we want somebody to come and inspect the box before we offload. So you so that. But I and I.

**Interviewer: So what I hear is, this process works best for large scale exporters and large-scale farmers. Would we integrate smallholders because for the avocados what we have is smallholders and the harvesting is done through the cooperative. How would we ensure that then we are involving smallholders in such a process?**

Interviewee: Yeah, I think there are. So one way of course. So as more what is a small grower, how much, what is the typical production they would have?

**Interviewer: So not too many trees. So what they do is harvest at harvest time and then aggregate through the cooperative to increase the volumes.**

Interviewee: I say once they have it and they start cooling them that at that point they add the data logger. Cool them immediately like they do with flowers. But do these small holders, do they have? Do they even have cold rooms?

**Interviewer: No, they do not. They do not. They solely rely on the buyers, so they exporters. So it really is in the hands of the exporter. So for those that are not able to sell through the exporter, then we have all these losses going on, yeah.**

Interviewee: We would of course need to make sure that that is a cool truck we could bring it into. And I think then in that truck you could have a have a data logger, you could have a monitor on that truck that would make sure that the temperature is right. And then once it gets to a bigger facility where you actually pack and consolidate.

For example, on I talk a lot about flowers because we do a lot of flowers, but there is an independent company flower watch that. It is like a consultancy company, but they have managed to build up a reputation and they have developed certification. So for example, I can tell you for flowers now, sea freight has become quite big and flower watch when they are involved.

Like in any other industry, you have people that are saying no, no, no, I do not believe in what they do, but I think generally they're quite well recognized as in a party, a neutral party that will somehow certify the process. So that would be another way of doing it. You know if there was maybe a nonprofit because of the whole project. So if there was like a nonprofit organization because this cloud watch, it is a commercial organization, it is a private company and of course, they want to make money.

But I think even if you had like a nonprofit to actually help these farmers, with some government aid that could also develop. So if you had, because, again, Keats and Sunrise, that's set up. And I'm sure that's working, I'm sure that's not where the loss is, right. The loss is for when they're selling to other people.

**Interviewer: Yes.**

Interviewee: So if you if you had a similar setup where but just as a theoretical example, if you had its own and you had this this, this body or whatever it is a neutral party who could be there as to

observe, because then, and if it's a nonprofit organization, of course there's a cost to it, but that might actually be less costly than a data logger.

**Interviewer: OK. And all these ties in because a lot of the farmers are some of the farmers that I talked to do not have information enough information about the pricing, about their quantities, about all that. So it is basically reliant on the exporter. So how, what, what would they borrow, for example, from the flower industry in terms of sharing information about pricing and quantities and all that flow so that it is clear from the very beginning, this is the quantity that we have from you. At this price, and this is how the payment is going to be affected, because that is still opaque as far as the smallholders are concerned.**

Interviewee: Yeah, so, so on the, on the flower side, so you have to you have at the high level, you have two, you have your selling F FCA FOB or you're selling CIF. So the CIF is typically for two detached options cloud auctions. So there is the farmer, and the farmer does not obviously know whether he will get \$0.10 or \$0.50 for his roses or roses for that matter

And I think they have more because they do, they do contracts for a period of time as far as I know, we do not get involved in that part. So they but they will contract the farm for a period of time. And I think they guarantee certain volumes and the farm in turn guarantee certain pricing on the FOB side and I, but I think I mean for, but I think that would be the same for avocados because the retail price is very transparent.

**Interviewer: Another and this is I think you've, uh, kind of touched on it, but your business model you know how we ensure because they also have to build their business model so that it's not just the economic level, but we're also incorporating you know other social responsibilities and to the environment. So how can they structure that so that they are capturing all that it is a sustainable business model basically.**

I think I think you have. I think there are some official certifications now. but obviously you cannot. You cannot ask a. You cannot ask a small holding to be ISO certified.

**Interviewer: OK. And I think because a lot of not a lot there because the farmers are doing the avocado of production and marketing through the cooperative, perhaps that would be an area of leverage for the cooperative to do this for their members.**

Interviewee: That would be the way to do it.

**Interviewer: Any CSR activities your company is involved with?**

Interviewee: Yeah. Well, we, we've it is. Yeah, it has been it has been a little bit on hold due to COVID, but we did a couple of years we did you know there are a couple of course you know very well-being Kenyan and there's a couple of children's homes etcetera.

A nonprofit organization in in Kibera called Carolina for Kibera. We collaborated with them, and we went there with similar maze and a lot of things part that we had bought and part that we had collected from sponsors.

**Interviewer: Yeah. So and this and this, this is helpful because our leveraging from the cooperative is something that can be skilled back down to the smallholder and then back up to the exporting levels. So that is helpful, you know and the other ICT expert I have talked to have talked about you know embracing blockchain and the IoT, which is what you are talking about. So it is just finding a way of putting all this together into ways that will include.**

Interviewee: Absolutely, absolutely. But I can I think I think because of ready now, I think you know some of the big pharma companies, I think you can even you can even have whatever we want to call it traceability on it on a tablet level and so, so it is that advanced. So I think, but obviously it is because it is the, the cost and the retail price is a lot higher.

So I think I do not know, 5-10, maybe 10, maybe it's longer years from now. I am sure the avocados and even a stem flowers them can be grown with some sort of a data logger in the not in the middle of the avocado that can actually trace it all the way. Yeah. But before we get there, we need to have some solutions.

**Interviewer: Yeah, it's teething problems and you know, figuring out how to put all these components together in a way that works for, for their value chain at that level, yeah.**

Interviewee: No, absolutely. And if I think of anything else, I will, I will let you know. Yeah. Thank you and good luck to you.

## Annex 14 Interview Transcript Nandi County Government Representative

### Interview Transcript – Agricultural Officer – Nandi County Government

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interviewee is Nancy Jerop, and Agriculture Officer with the Nandi County Government.**

**Interviewer: Please tell me about avocado farming in Nandi County.**

Interviewee: Avocado farming is practiced by 36% of households in Nandi County. Registered avocado farmers are 647 with 938.2 acres of land under avocado farming. The current production is currently 6,739 MT per season. There are also farmers who have planted avocados but have not yet harvested.

**Interviewer: Nandi is known for tea production, why the focus on avocado?**

Interviewee: The main reason is to diversify into other crops. Tea is also fetching lower prices in the market, management practices for tea farms are high and those for avocado farming are easier and lower because all that's needed is weeding and pruning the trees at intervals. Avocados are also attracting good prices up to Ksh 100 per kg currently, so the gross margin from avocado is higher. However, most farmers are still intercropping their avocados with tea.

**Interviewer: What is the demographic of the avocado farmers?**

Interviewee: We have a mix of ages, from young people even 25 years of age to older people. It attracts many retirees who previously had avocado trees but are now beginning to do it as a business.

**Interviewer: Avocado is a new chain, what specific measures are being taken by the county to ensure the chain develops?**

Interviewee: We are ensuring provision of high-quality seedlings to farmers. We also have partnerships e.g. with the NARIG project to provide technical assistance to farmers. Funding is also provided to the cooperative for marketing purposes. Extension services are available for farmers to ensure their trees are growing according to market requirements.

**Interviewer: Are the avocados grown for export or for domestic consumption**

Interviewee: It is done for both export and for the domestic markets and also because of the nutritional value of avocados, we also encourage farmers to ensure they are also including avocados in their diets.

**Interviewer: How then do you ensure you are meeting export standards?**

Interviewee: We are encouraging our farmers to do more of organic farming to reduce chemical use. We also conduct GAP training and also partner with organic farming companies to train farmers. The export companies also partner with farmers e.g. Sunripe has been doing this for the 3<sup>rd</sup> year now and they provide training to farmers on GAP and export standards. The export companies, Sunripe and Keitt also to the harvesting and transporting of the avocados when ready.

**Interviewer: To ensure traceability in the avocado chain, what can be done to ensure all stakeholders are included?**

Interviewee: We need more funding to implement the required standards, and also partnerships and cooperation among the various stakeholders in the value chain. With all working together, it can be possible to have traceability that includes everyone.

The farmers produce the avocados are exporters will harvest and transport to their pack houses. So the traceability for farmers ends at the pack houses. Ideally, the cooperative needs its own packhouse so as to monitor the avocado processing at different stages.

The traceability being done is on things like seedlings from certified nurseries. Because nurseries must be registered with the HCDA, this can be traced. But no ICT is currently being used.

**Interviewer: Do you have any quantitative data on the exports so far?**

Interviewee: In 2020 when we began, the exports were low. About 10MT. In 2022, we have so far done 20MT and harvesting is still ongoing.

**Interviewer: How is payments to farmers done?**

Interviewee: The exporter pays the farmers through the cooperative depending on volumes supplied and quantity rejected. It's at the packhouse that farmers know which of their avocados have been rejected.

The exporter controls the price depending on global market prices, so it fluctuates. Avocados not exported and rejects e.g. because of odd shapes, size or bruises are used to process oil. Sometimes, the avocados are left to farmers who then use them to feed animals or just throw them away, which is a loss for farmers. There is currently no processor for oil in Nandi County.

**Interviewer: How does information flow along the value chain in the County?**

Interviewee: We send messages and SMSs to farmers o information like harvesting for particular zones and pricing.

This is also for the partners we work with e.g. Sasini Nandi Sub County that provides seedlings for farmers not in the cooperative, APEX that works with contract farmers and the NARIG project. We however have no direct linkages with importers.

But there is a commitment to use more in technology for communication and traceability so that we are meeting market standards. This is because the chain is growing, and traceability is a core focus in any avocado value chain.

**Interviewer: What is the 5-year plan concerning the avocado value chain in Nandi County?**

Interviewee: We want to increase production so there is more income to farmers. We also want to use technology in our tracing process so that farmers know where their fruits go and because this will improve the quality of avocados, more will be exported. We want to see high growth in the avocado value chain.

## Annex 15 Interview Transcript Nandi Avocado Cooperative Secretary

### Interview Transcript – Nandi Avocado Cooperative Secretary and Producer – John Misoi

**(Researcher introduced herself and the study, reiterated the confidentiality nature of information provided and information will be used solely for the purpose of the study) The interviewee is John Misoi, a producer, and Secretary at Nandi Avocado Cooperative Society.**

**Interviewer: Please tell me more about the operations of the cooperative?**

Interviewee: I am the record keeper and custodian of all documentation at the cooperative. The membership of avocado farmers is 949; 360 female and 589 males. The age range of the farmers is 25-100 years old.

**Interviewer: What are the functions of the cooperative?**

Interviewee: The cooperative is for the farmers, so really it is to assist farmers in all areas of avocado production e.g. provision of seedlings, GAP and marketing of the avocados produced.

**Interviewer: How do you market the avocados produced?**

Interviewee: Right now we are working with 2 companies, Sunripe and KEITT, who harvest and purchase all the avocados.

**Interviewer: How do you communicate with farmers?**

Interviewee: We send phone messages to farmers when the avocados are ready to be harvested then the exporter harvests and aggregates the avocados. They then issue each farmer with the quantity of avocados harvested from each of them.

The exporter then sends a check to the cooperative account and then this is disbursed to the farmers. Because the farmers are selling together, their bargaining power is improved a bit unlike if they were selling individually.

**Interviewer: How do members join the cooperative?**

Interviewee: They join by paying Ksh. 500 using the Paybill (MPESA). We use technology to send messages to farmers e.g. social media like Facebook, WhatsApp, and SMS for those without smartphones. Farmers can also pay using Equity Bank's Eazybizz that has no charges to them.

Meetings are organized in the different wards at ward level each quarter and then there is the AGM where all farmers are present.

**Interviewer: Who are some of the partners you work with?**

Interviewee: Safaricom, JICA, Equity Bank through the Mastercard Foundation, NARIG and the County Government of Nandi.

**Interviewer: How do you ensure you are getting the quality of avocados required?**

Interviewee: Nandi County has a good environment for avocado production, but there are still issues we deal with e.g. pests and diseases, hailstorms that destroy the trees and production of certified fruits. We have begun capacity building at Ward level on production of avocados and also to leverage on the experience from tea farming.

Exporters can partner with us in providing the right gadgets for harvesting, providing information and the right chemicals.

Right now, we are marketing by aggregating from all the wards so that we have enough volumes.

# Annex 16 Triple Layered Business Model Canvas Nandi Avocado Cooperative Society

## Economic Layer

<b>Key Partners</b> <ul style="list-style-type: none"> <li>Producers</li> <li>Exporters</li> <li>Nandi County Government</li> <li>Traders</li> <li>World Bank (NARIG)</li> </ul>	<b>Key Activities</b> <ul style="list-style-type: none"> <li>Production</li> <li>Marketing</li> <li>Training of members</li> </ul>	<b>Value Proposition</b> <ul style="list-style-type: none"> <li>Fresh safe avocados</li> <li>Organic avocados</li> <li>Locally grown avocados</li> <li>Better prices for farmers.</li> <li>Embedded services</li> </ul>	<b>Customer Relationships</b> <ul style="list-style-type: none"> <li>Direct contact with buyers</li> <li>Long term relationships</li> </ul>	<b>Customer Segments</b> <ul style="list-style-type: none"> <li>Exporters</li> <li>Wholesalers</li> <li>Oil and cosmetic processors</li> </ul>
<b>Key Resources</b> <ul style="list-style-type: none"> <li>Members land</li> <li>Staff</li> </ul>		<b>Channels</b> <ul style="list-style-type: none"> <li>B2B (Exporters)</li> <li>Wholesalers</li> <li>Bulk and retail</li> </ul>		
<b>Cost Structure</b> <ul style="list-style-type: none"> <li>Salaries</li> <li>Utilities</li> <li>Marketing</li> </ul>			<b>Revenue Streams</b> <ul style="list-style-type: none"> <li>Memberships fees</li> <li>Funding from Nandi County Government</li> <li>Funding from partners e.g. NARIG</li> </ul>	

## Environmental Layer

<b>Supplies and Sourcing</b> <ul style="list-style-type: none"> <li>Avocado Seedlings</li> </ul>	<b>Production</b> <ul style="list-style-type: none"> <li>Fresh avocados</li> <li>Avocado Oil</li> <li>Cosmetics</li> </ul>	<b>Functional Value</b> <ul style="list-style-type: none"> <li>Avocados for export</li> <li>Avocados for domestic market</li> <li>Rejected avocado for oil processing</li> </ul>	<b>End of life</b> <ul style="list-style-type: none"> <li>60% losses in harvested avocado</li> </ul>	<b>Use Phase</b> <ul style="list-style-type: none"> <li>No processing at cooperative level</li> </ul>
<b>Materials</b> <ul style="list-style-type: none"> <li>Land</li> <li>Seedlings</li> <li>Organic manure</li> </ul>		<b>Distribution</b> <ul style="list-style-type: none"> <li>Exporter trucks</li> <li>Informal transportation e.g. <i>matatus</i></li> </ul>		
<b>Environmental Impacts</b> <ul style="list-style-type: none"> <li>Deforestation to make more land for avocados</li> <li>Shift from tea farming</li> </ul>			<b>Environmental Benefits</b> <ul style="list-style-type: none"> <li>Intercropping</li> <li>Crop diversification</li> </ul>	

## Social Stakeholder Layer

<b>Local Communities</b> <ul style="list-style-type: none"> <li>Approximately 950 farmers in cooperative</li> <li>Smallholder production</li> <li>Family farms</li> </ul>	<b>Governance</b> <ul style="list-style-type: none"> <li>Dependent on Nandi County Government</li> </ul>	<b>Social Value</b> <ul style="list-style-type: none"> <li>Production of quality avocados</li> <li>Improved farmer livelihoods</li> </ul>	<b>Societal Culture</b> <ul style="list-style-type: none"> <li>Family farms</li> <li>Close knit societal relationships</li> </ul>	<b>End User</b> <ul style="list-style-type: none"> <li>Export grade avocados</li> <li>Safe and nutritious avocados</li> </ul>
<b>Employees</b> <ul style="list-style-type: none"> <li>Embedded services to cooperative members</li> </ul>		<b>Scale of Outreach</b> <ul style="list-style-type: none"> <li>All 6 wards in Nandi County</li> </ul>		
<b>Social Impacts</b> <ul style="list-style-type: none"> <li>Shift from tea and maize farming</li> <li>Neglecting other agriculture sectors</li> </ul>			<b>Social Benefits</b> <ul style="list-style-type: none"> <li>Improved community livelihood e.g. hospital, schools</li> <li>Income earning avenue for retirees</li> <li>Improved livelihood for farmers</li> </ul>	

Source: Author's compilation

# Annex 17 Triple Layered Business Model Canvas APEAM

## Economic Layer

<b>Key Partners</b> <ul style="list-style-type: none"> <li>• Producers</li> <li>• Packing Houses</li> <li>• Local Municipality Authorities</li> </ul>	<b>Key Activities</b> <ul style="list-style-type: none"> <li>• Production</li> <li>• Marketing</li> <li>• Packing and Export</li> </ul>	<b>Value Proposition</b> <ul style="list-style-type: none"> <li>• End to end traceability</li> <li>• Fresh safe avocados</li> <li>• Organic avocados</li> <li>• Locally grown avocados</li> <li>• Better prices for farmers.</li> <li>• Embedded services</li> </ul>	<b>Customer Relationships</b> <ul style="list-style-type: none"> <li>• End to end contact with buyers</li> <li>• Long term relationships</li> </ul>	<b>Customer Segments</b> <ul style="list-style-type: none"> <li>• Pack houses and distribution centers in the USA</li> </ul>
<b>Key Resources</b> <ul style="list-style-type: none"> <li>• 42,000 avocado orchards</li> <li>• 338,500 acres of land</li> <li>• Skilled workers</li> </ul>		<b>Channels</b> <ul style="list-style-type: none"> <li>• B2B - Mexico to USA</li> </ul>		
<b>Cost Structure</b> <ul style="list-style-type: none"> <li>Salaries</li> <li>Utilities</li> <li>Marketing</li> <li>Processing</li> <li>Transportation</li> <li>Certification</li> </ul>			<b>Revenue Streams</b> <ul style="list-style-type: none"> <li>• Avocado exports</li> <li>• Avocado sold in domestic markets</li> </ul>	

## Environmental Layer

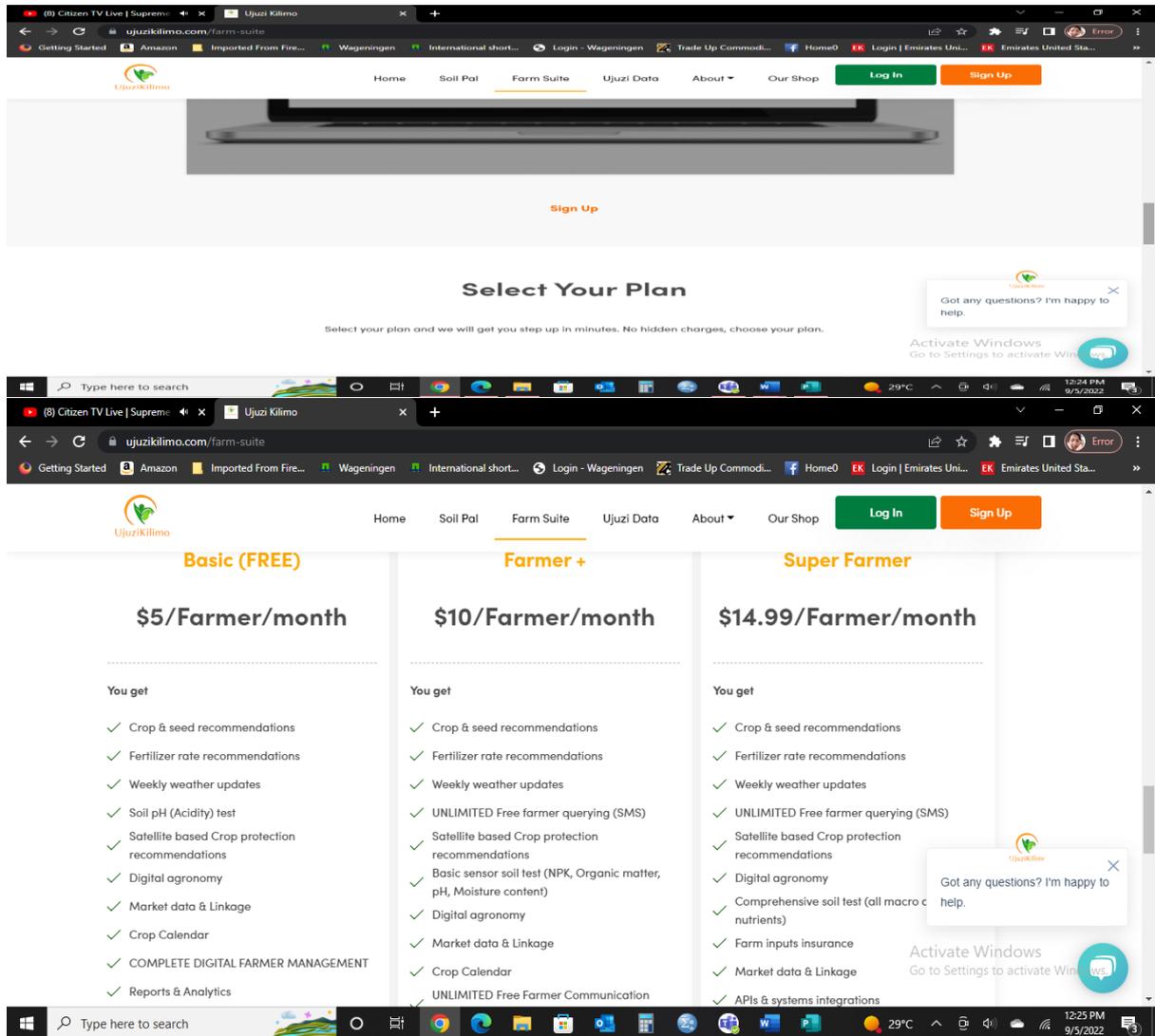
<b>Supplies and Sourcing</b> <ul style="list-style-type: none"> <li>• Certified Avocado Seedlings</li> <li>• Phytosanitary disinfectants</li> <li>• Equipment for harvesting</li> <li>• 74 packing houses</li> <li>• Traceability crates and stickers</li> </ul>	<b>Production</b> <ul style="list-style-type: none"> <li>• Fresh export grade avocados</li> </ul>	<b>Functional Value</b> <ul style="list-style-type: none"> <li>• Grade 1 export quality avocados</li> </ul>	<b>End of life</b> <ul style="list-style-type: none"> <li>• Waste from processing used for composting</li> </ul>	<b>Use Phase</b> <ul style="list-style-type: none"> <li>• All round power use at processing plants for automated systems.</li> </ul>
<b>Materials</b> <ul style="list-style-type: none"> <li>• Well developed land</li> <li>• Certified seedlings</li> <li>• Cold storage trucks</li> </ul>		<b>Distribution</b> <ul style="list-style-type: none"> <li>• Cold storage trucks</li> <li>• Distribution centers and pack houses</li> </ul>		
<b>Environmental Impacts</b> <ul style="list-style-type: none"> <li>• Deforestation to make more land for avocados</li> <li>• Water shortages</li> <li>• Loss of biodiversity</li> </ul>			<b>Environmental Benefits</b> <ul style="list-style-type: none"> <li>•</li> </ul>	

## Social Stakeholder Layer

<b>Local Communities</b> <ul style="list-style-type: none"> <li>• 30,000 farmers</li> <li>• Smallholder production</li> <li>• Family farms</li> <li>• Integrated smallholder farms</li> </ul>	<b>Governance</b> <ul style="list-style-type: none"> <li>• Formal organization through APEAM</li> <li>• Coordination through Municipalities</li> </ul>	<b>Social Value</b> <ul style="list-style-type: none"> <li>• Production of Export quality avocados</li> <li>• Improved farmer livelihoods</li> <li>• Year round production</li> </ul>	<b>Societal Culture</b> <ul style="list-style-type: none"> <li>• Family farms</li> <li>• Close knit societal relationships</li> </ul>	<b>End User</b> <ul style="list-style-type: none"> <li>• Export grade avocados</li> <li>• Safe and nutritious avocados</li> <li>• Year round availability</li> </ul>
<b>Employees</b> <ul style="list-style-type: none"> <li>• Embedded services to cooperative members</li> <li>• Well trained and skilled employees</li> </ul>		<b>Scale of Outreach</b> <ul style="list-style-type: none"> <li>• 39 municipalities in Michoacan</li> <li>• Global distribution</li> </ul>		
<b>Social Impacts</b> <ul style="list-style-type: none"> <li>• Increase in organized crime from cartels</li> <li>• Health problems for people in avocado belt due to pesticide use</li> </ul>			<b>Social Benefits</b> <ul style="list-style-type: none"> <li>• Improved livelihoods for farmers</li> <li>• Job creation in the avocado value chain</li> <li>• Nutritional benefits of avocados in meals</li> </ul>	

Source: Author's compilation

# Annex 18 UjuziKilimo FarmSuite



Source: <https://www.ujuzikilimo.com/farm-suite>