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## Title

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

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

A research thesis submitted to Van Hall Larenstein University of Applied Sciences in partial fulfilment of the requirements for the degree of Master of Science in Agricultural Production Chain Management specialization Forest Chain

This research has been carried out as part of Food Waste Reduction and Food Quality Living LAB FORQLAB – Kenya Project - PVG.DZ21.04.001

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**Dedication**

My dissertation is dedicated to my mentors, family, and friends. A special thanks to Dr. Israel Nyaburi, who helped me get to where I am today and whose words of encouragement and push for tenacity still ring in my ears. I also dedicate this dissertation to myself for remaining strong throughout the master's program.

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## Acronyms

AVC: Avocado Value Chain

**FAO:** Food and Agriculture Organization

**FLW:** Food Loss and Waste

**FSC:** Food Supply Chain

**FVC:** Food Value Chain

**GAP:** Good Agriculture Practice

**HCD:** Horticultural Crops Directorate

**KALRO:** Kenya Agriculture and Livestock Research Organization

**KEBS:** Kenya Bureau of Standards

**KES:** Kenyan Shillings

**NAFCS:** Nandi Avocado Farmers' Cooperative Society

**MT:** Metric Tons

**PHL:** Post-harvest Losses

**UN:** United Nation

## Executive Summary

The main objective of this study was to analyse food loss and waste (FLW) at the production, collection, processing, distribution, and consumption level with focus on smallholder farmers in avocado value chain in Nandi County, Kenya. The findings from this study show that there is high rate of FLW produced in avocado value chain in Nandi County. The overall FLW (production including on-farm to consumer level) was estimated at 343,412kg/year where the production level had the highest potion of losses at 90%. Post-harvest losses (PHL) were estimated at 31,542kg/year where processing and packaging recorded the highest losses at about 49% followed by storage and collection at 26% and distribution contributed to 25% of the PHL. Analysis of this study shows that losses at the production are associated with poor agricultural practises in addition to inaccessibility to market leaving high portion of avocado unharvested. PHL is attributed by lack of cooling storage in Nandi, bulk packaging and transport to the processing/market which are the root cause of physical damage of avocado fruit. Consumption level recorded the least losses at 1% of the overall FLW which are associated with consumers' behaviour of purchasing avocado which exceed their consumption rate.

Main critical loss points identified include production stage (On-farm and harvesting), storage, transportation to collection centre and to the processing companies. FLW was found to have negative effects on economic value at an estimate of KES. 33Million with production recording the highest portion at 52%, whereas processing and packaging was estimated at 39%, storage and collection at 7%, while distribution was approximately 5% respectively. Results on effects on FLW on carbon footprint was at an elevated level of GHG emissions estimated at 652483 $CO_2$-e/kg. Production level recorded the highest carbon footprint at 90% due to high rate of FLW. The high carbon food print in Nandi is because of poor management of avocado which most end up in Landfills.

Based on these results various interventions were recommended to facilitate the reduction and mitigation of FLW in avocado value chain in Nandi County. This include enhancing of sustainable agricultural practices among the smallholder farmers, establishment of low-cost cold storage aggregation area and introduction of agro-processing facility by the cooperative. Finally, collaboration through public private partnership will improve the robustness of the value chain thus reducing overall FLW.

# CHAPTER 1

## 1.0 Introduction

### 1.1 Background

Avocado trees are native to Central America and Mexico and belong to the Lauraceae family. The genus Perseal has two subgenera: Eriodapne and Persea (Duarte *et al.*, 2016). Further classification includes Mexican and west Indian types which belongs to *Percea americana*, Guatemalan (*Persea nubigena Mill*), and Hybrids. A Guatemalan race, Hass avocado is the main variety produced widely for commercial purpose. Avocado is a tropical fruit whose consumption has increased drastically (Pedreschi *et al.*, 2019). New varieties of Hass such as Lamb Hass, Lavi Hass and Gem Hass have also been introduced to help in extension of supply season (CBI, 2022).

Avocado is widely distributed since the last 400 years and it is recognized due to its nutritional and economic value (Selamawit *et al.*, 2019). The fruit has been introduced to over 50 countries during the last century in both tropical and sub-tropical regions of Africa (Biazin *et al.*, 2018). Avocado consist of a bigger portion in the world's export in horticultural industry (European Union, 2020) with global production of avocado being approximately 8.06 million metric tons increasing from 2007 to 2020 by about 20% (FAO stat, 2022). Among the top producers of avocado include Mexico which produces about 2.4 metric tonnes followed by Colombia and Dominican republic (FAO, 2022).

Kenya is Africa's biggest avocado producer and exporter. In 2020, Kenya was ranked sixth after Indonesia producing approximately 322.56 metric tons (FAO Stat, 2022). Avocado subsector contributes to KES. 4.26 Billion accounting for 84.48% of the export industry in Kenya (Directorate, 2019). Good climatic conditions with favourable agro-ecological diversity has contributed to the expansion of avocado sector (Snel *et al.*, 2021). Additionally, high demand at local, regional, and international level has influenced increase in production to meet the needs of growing demand. The most common produced include Hass, Fuerte and Jumbo (Kathula, 2021). Muranga County is Kenya's top producer, accounting for 31% of the country's total output. Other counties include Kiambu, Kisii, Nyamira and Meru. Furthermore, other counties such as Nandi is among the few who have recently ventured on avocado production for commercial purpose (Directorate, 2019).

To satisfy the need of the growing market demand, focus has been on increasing the avocado production with farmers from counties such as Nandi switching to avocado farming as it is considered profitable. However, avocado being part of food supply chain, there has been less attention on the quantification and mitigation of food losses and waste (FLW) within the avocado chain. FLW is defined as reduction of food quality and quantity from the production to the consumer (FAO, 2011). Avocado has socio-economic values hence the need to reduce losses and waste to not only increase financial benefits but also fight food insecurity. According to Snel *et al.,* (2021), the avocado value chain in Kenya experience about 35% loss despite being ranked eleventh largest exporter in the world. The potential hotspots for losses is during harvesting, storage, transportation and trading level (Owuor, 2020). Among the Kenya's smallholder farmers, harvesting process is the traditional way of shaking and collecting fallen avocado, there is less emphasis on proper fruit transportation and storage. These increases chances of rejection as the quality is poor thus contributing to food loss and waste across the country (Selamawit *et al.*, 2019).

Quantification of the actual losses and waste along food supply chains and value chains has become centre of attention and considered significant for reduction options (Redlingshöfer, Coudurier and

Georget, 2017). Recent research shows that avocado losses are more predominant at the harvesting level and opines that actual losses at the market level are poorly understood since the detreated produce are usually sold at a very low price thus representing unknown economic loss (Luo *et al.*, 2021: Snel *et al.*, 2021:van Berkum, Dengerink and Ruben, 2018).

The problem of FLW has economic, environmental and social effects which affects the farmers and all stakeholders along the value chain. Gogh *et al.*, (2017) links FLW and postharvest management to five societal themes (food security, climate footprint, employment, economic revenue, and food safety). It assumes that the themes have specific correlation with post-harvest management which consequently influence the entire value chain. Hence, effects of FLW within the food supply chain and value chain have consequences in economic, social and environmental aspects especially in developing countries (Arias Bustos and Moors, 2018).

Avocado availability, cost, and food security are all impacted by FLW. According to Jalata, (2021) avocado is recommendable for people with nutritional deficiency in developing countries. Even though investments in post-harvest handling along the export chain Kenya has alleviated post-harvest losses there is still a gap at the local and regional markets dominated by smallholder farmers. Furthermore, being a complementary advantage for the economy in rural communities, the outcome of continuous loss of avocado results to loss of employment as avocado sector which has become lucrative venture with majority of farmers shifting from local crops to avocado farming. Consequently, FLW has a huge negative impact on economic value which affect the government through the loss of revenues from both local market and export (Ishangulyyev, Kim and Lee, 2019).

Moreover, FLW has contributed to the increase in greenhouse emissions. The environmental impact of these losses results to increase in costs of managing the waste and also decomposing avocado results to emission of methane and carbon dioxide (López-Sánchez *et al.*, 2021). Effects of Food wastage on natural resources has been quantified notably through carbon footprint (Eriksson, Strid and Hansson, 2015) . According to FAO, (2015) carbon footprint of a food product refers to the total amount of greenhouse gas emitted throughout the life cycle and it is usually expressed in kilograms of CO2-equivalents. The carbon footprint of FLW globally is estimated at 3.3 gigatons of Carbon equivalent (FAO, 2015). This study provides descriptive research aims at analysing the loss and waste along the avocado chain among the smallholder farmers in Nandi, county as part of FORQLAB project for the development of chain interventions.

## 1.2 Problem Statement

Although Kenyan avocado production is growing in popularity around the world insufficient information flow within the avocado value chain among the smallholder farmers has been identified as the main problem that contribute to avocado losses and waste. Kenya is currently one of the top producers and exporters of avocados. While its export and domestic markets are significantly increasing, issues related to avocado losses has become a constraint in the avocado value chain in Kenya. Current estimated of avocado loss is approximately 35% (Snel *et al.*, 2018) while information of these losses in individual production areas/counties is still insufficient. Avocado production is practiced by smallholder farmers who are characterized by limited access to improved seedlings variety, knowledge on silvicultural practices and poor pest and diseases management practices.

Even though high losses are reported to occur at post-harvest stages estimated 20 to 50% in both fruits and vegetable in developing countries (Hailu and Derbew, 2015) there is still insufficient information about on-farm losses. Other chain actors such as the processors and distributors have little information on proper storage and transportation of avocado especially in developing value chains. Besides resulting into negative effects ranging from economic to the environmental effects, there has been insufficient studies related to effects of FLW in economic value and carbon footprint in avocado chain particularly in developing counties like Kenya. Information on proper management of avocado waste is still scanty since avocado value chain is still at its developmental. All these setbacks are linked to insufficient information related to post-harvest handling

Nandi County Avocado Cooperative Society (NCAC) has shown progressive commitment to support avocado farmers in Nandi area. Since its inception in 2019, the key role has been to connecting farmers to the market and negotiating prices. However, the cooperative has not been able to fully implement other roles of cooperative such as increase crop production, credit facilities and introduction of other activities that impact the smallholder farmers as described by (James and Joshua, 2014).

Currently, information on the issues related avocado losses, waste, and the causes of the losses within the value chain remain unaddressed in Nandi. Analysis of FLW in avocado value chain in Nandi is important as it will provide a basis of managing current food losses and waste along the avocado value chain. It will contribute to development of sustainable agricultural system; it helps in addressing global issues of food losses and waste and influence policy changes. Additionally, it also contributes to new knowledge in research as there is no sufficient information about losses and waste within avocado value chain at local/regional level.

### 1.3 Problem Owner

The problem owner is FORQLAB and avocado chain actors (Producers, traders, processors, NAFCS) in Nandi. Food Waste Reduction and Food Quality Living LAB (FORQLAB) is a project that aims at structural reduction of post-harvest and food loses with the goal of improving the quality of avocado chain.

**Problem Tree**

The main problem in this study is insufficient information regarding FLW. This is linked to poor coordination between the current stakeholders particularly NAFCS with the farmers. Poor horizontal and vertical cooperation along the chain results to low efficiency and effectiveness as described by Wankmüller and Reiner, (2019). The leading effect of poor coordination is market inaccessibility among the smallholder farmers and inadequate application of advance technology at the production level, storage and transportation to market/processing. This is also due to insufficient incentive to promote sustainable agriculture. Ineffective partnership along the value chain hinders avocado value chain in Nandi from reaching its maximum potential and competitiveness. All these are associated with insufficient information flow regarding FLW thus increase in FLW in avocado value chain in Nandi.

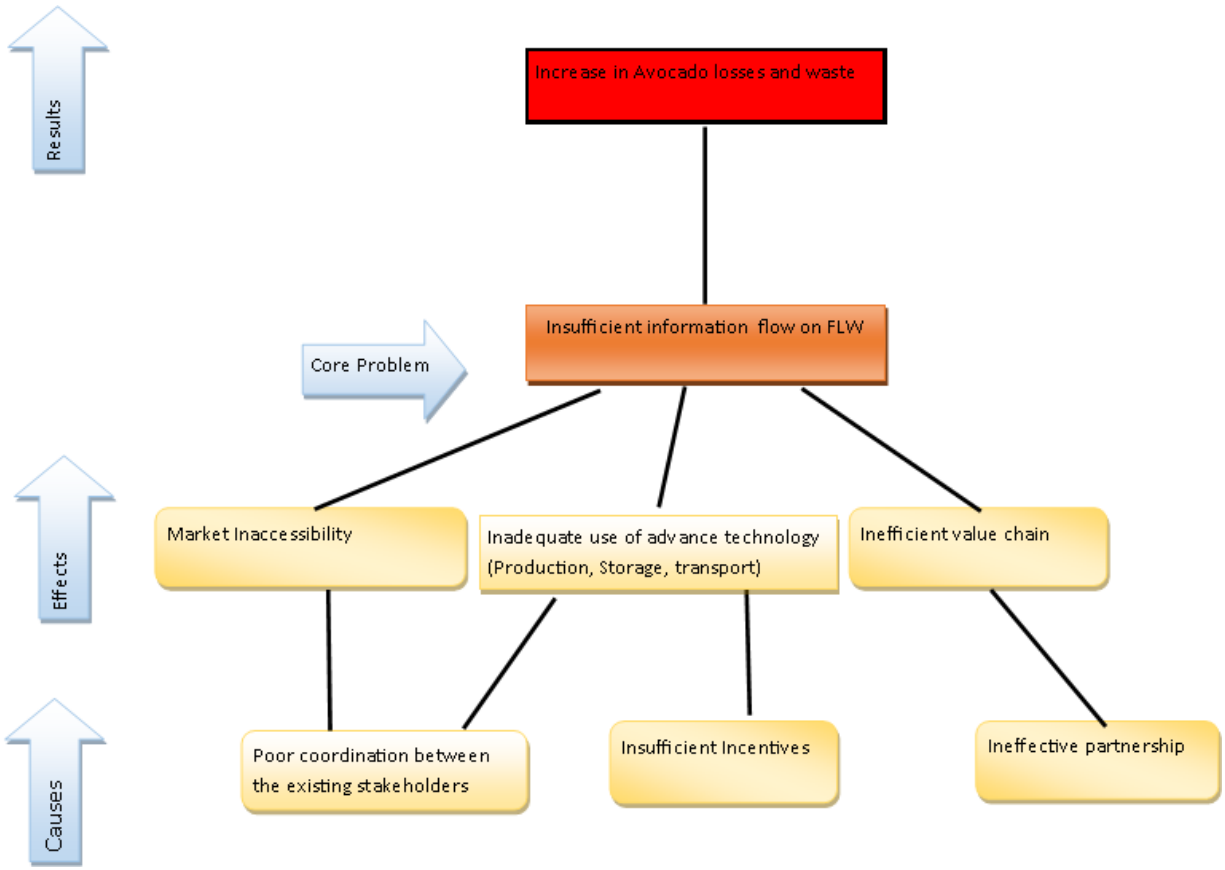



*Figure 1: Problem Tree*

Source: Author

## 1.4 Scope of the study

This research project focuses on the key issues related to food losses and waste within the avocado value chain in Nandi, Kenya. It will also consider the actual losses and waste, the main causes and effects of these avocado losses and waste within the chain. The results of this study will be used to produce strategies of reducing FLW in Nandi avocado as part of FORQLAB project whose objective is to contribute to structural reduction of post-harvest losses of avocado in Kenya.

## 1.5 Research Objective

To analyse avocado losses and waste at the production, collection, processing, distribution, and consumer levels with focus on smallholder farmers in avocado value chain in Nandi country, Kenya with the aim of formulating recommendations to both FORQLAB, Nandi County Avocado Cooperative Society and avocado chain actors in Nandi for interventions for structural reduction of post-harvest losses and food losses in avocado value chain.

## 1.6 Research Questions

1. What are the estimated quantities of FLW within the avocado value chain in Nandi?
   a) What is the current nature of the avocado value chain in Nandi?
   b) What are the actual FLW in the avocado value chain in Nandi?
2. What are the causes and critical loss points for FLW reduction within the avocado value chain in Nandi?
   a) What are the drivers of FLW within the avocado value chain in Nandi, Kenya?
   b) What are the critical points of avocado losses and waste within the Nandi value chain?
3. What are the economic effects and carbon footprint of FLW in avocado value chain in Nandi?
   a) What are the effects of FLW on economic value in Nandi?
   b) What is total carbon footprint of avocado waste in Nandi?

# CHAPTER 2

## 2.0 Literature overview of food loss and waste

### 2.1 Overview of previous research

Food loss and waste has been used to describe the total quantity of losses and wastes within various levels of the food supply chain (FSC) which involves the production, collection, storage, processing, distribution and consumption (Vilariño, Franco and Quarrington, 2017). However, FLW has no single definition. According to EU *"Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed"* this includes crops ploughed in/not harvested, bio-energy production, anaerobic generation, disposed to landfill, sea or sewer, incineration, composited, and cogeneration (CBI, 2022).

FAO, (2018) defines FLW is defined as the weight or quality reduction of edible product meant for consumption which takes place at the production, post-harvest and processing stages of the food supply chain while food waste is defined as food fit for human consumption but has been disposed before or after spoilage and mostly occurs at the end of the food chain (retail and consumption). This definition is most preferred in food loss and waste research as it gives a clear contrast for both food and food supply chain (Timmerman *et al.,* 2014). This research will focus on this definition.

Food losses and waste is estimated one third to half of the total production globally (Arias Bustos and Moors, 2018). Studying Food loss and waste (FLW) is important because of its high socio-economic costs along the value chain (Chauhan *et al.*, 2021). Avocado losses and waste can occur at any level along the food value chain. Potential phases for avocado losses and waste have been reported at the transportation level, storage, wholesale and retail levels with recent study showing approximately 20 percent losses being recorded at the harvesting level in Kenya (Snel *et al.,* 2021). Moreover, the study shows domestic value chain dominated by smallholder farmers at the producer level records a higher loss compared to the export chain. Currently, FLW in avocado value chain is not well explored particularly the developing chain like in Nandi. Moreover recent research by Snel *et al.*, (2018) only focused on post-harvest losses (PHL) with little consideration on on-farm losses. A holistic illustration is needed for overall FLW occurrences along the avocado value chain in Nandi in order to come up with ways stakeholders can apply to avoid FLW (Luo *et al.*, 2021).

Generally, as opposed to domestic chain the export market is formal, well structured, with focus on quality standards hence less post-harvest losses are experienced (Snel,Broeze, and Kremer, 2021). Traceability through certificates such as SPS and GAP are imperative for exports in Kenya (Kathula, 2021). Majority of farmers in Kenya are not able to meet such stringed measures. Smallholder producers who dominate the production sector have failed to fulfil these export requirement, whilst the large-scale farmers who are well equipped produce high quality avocado that meets export market requirement (Snel, Broeze, and Kremer, 2021). The large scale companies that dominate avocado export market in Kenya include: Vegpro, East African Growers, Sunripe Company Limited, Keith, Kakuzi, *viz a vis* Kenyan Horticultural Exporters, Ideal, and Mutanda (Amare *et al.*, 2019). Despite this, there still a great deal of losses in both domestic and export chain with domestic chain experiencing high rate of FLW (Snel *et al.*, 2018)

Chauhan *et al.*, (2021) reviews two major divisions of two major factors that cause FLW where the first one focuses on particular factors such as stakeholder attitude, improper packaging, supply chain

interruption, spoilable food managements and stringent quality standards. The second one is referred to the enlisted factors such as transport issues, unskilled labour, limited cold storage facilities, quality errors, limited innovations and technologies among other. Luo *et a*l., (2021) provided a clear description of occurrences of FLW and possible drivers of theses loses within food supply chain. Potential causes of FLW at the production level have been linked to overproduction and inadequate technologies for cultivation and harvesting (Ishangulyyev, Kim and Lee, 2019).

Avocado tree produce high yield of fruits approximately 138 kilograms at 7 years after planting (Holzapfel *et al.*, 2017). However, avocado growth and development differs significantly based on variety. According to a guideline provided by KALRO, (2018) on avocado cultivation about 230 to 320 kg of avocado per tree per year depending of the age of the tree. Avocado maturation is complete after harvesting, with changes in metabolism and a high rate of respiration, resulting in a large level of ethylene production. Consequently the fruit is highly perishable resulting to the production of large amount of waste when poor post-harvest management is applied (Duarte *et al.*, 2016). Additionally, various factors enhance perishability which include mechanical damage, cut and compression, chemical and biochemical and physiological changes ( Gogh *et al.*, 2017).

Harvesting in Nandi is mainly by tree climbing, or the use of picking poles which results to physical damage (Mupeta, Mwasomola, and Haqbeen., 2022). The external effects are not observed immediately, however the pulp is usually affected either partially of completely darkens as the fruit ripens (Berkum, Dengerink and Ruben, 2018). Strategies to delay ripening are often applied to fruits destined for export to prevent overripening before their destined market however being a developing value chain, this might be lacking. Such processes involve use of cooling storage, prevention of mechanical injury and reduction of ethylene (Bustos and Moors, 2018). Kenya is experiencing losses of upto 20% mainly due to immature harvesting. According to Kathula, (2021), high demand of avocado in export market push farmers to harvest premature avocado which negatively affects traders, consumers and also the economy of Kenya.

Currently, Kenya has expanded production of agricultural produce such as avocado upto 80 percent particularly in rural area (Directorate, 2019). The farming system is dominated by smallholder farmers who are characterized by limited access to processing and storage facilities thus selling their produce at low prices during high peak (Snel, Broeze, and Kremer, 2021). Most of the time farmers are involved in more than one functions in the value chain such as the wholesaling which is characterized by lack of cooling systems and unsanitary. At times there are intermediaries such as traders who face the same problem which contribute to FLW (Selamawit *et al.*, 2019). FLW at the wholesaling level is a result of poor distribution channels and cooling storage in addition to insufficient information on postharvest handling of avocado ( Snel, Broeze, and Kremer, 2021). Although recent studies do not reflect FLW at the market stage in the domestic chain of avocado in Kenya, losses at the retailer level cannot be ruled out. According to Luo *et al.*, (2021) factors resulting to FLW at the retailer level are related to quality management, inventory management, and supply management.

Marketable production of Hass variety in Kenya was approximately 90,000 metric tons produced on 7,500 ha (Eurpoean Union, 2020). In 2020 production increased to 322,556 tons from 264,032 tons in 2019 (FAOSTAT, 2022) . Generally, records on export to EU market shows an increase of upto 47,000 metric tons in 2020 from 17,000 metric tons in 2010 (European Union, 2020). The Netherlands is the main destination of almost half of the avocado exports where Kenya accounts to 6% of its export to

the Netherland (CBI, 2022). Predictions by CBI (2022) shows that avocado is expected to lead in the export market after banana by 2030. 31% of the predicted global production is expected to be imported to the Europe market in 2030 with the Netherlands being the trading hub for avocado market accounting for 50% of the export market in EU (CBI, 2022). Despite being among the largest producer of avocado, Kenya's export market of avocado to Europe is still low compared to the production rate which is linked to increase of rejects related quality standards thus negatively impacted the economic value.

Table 1: Avocado Production in Kenya

| Year | Area harvested (Ha) | Yield (Ton/ha) | Production (Ton) |
|---|---|---|---|
| 2015 | 8,486 | 16.1 | 136,420 |
| 2016 | 10,305 | 17.1 | 176,045 |
| 2017 | 16,460 | 13.2 | 217,688 |
| 2018 | 14,497 | 16.1 | 233,933 |
| 2019 | 20,125 | 13.1 | 264,032 |
| 2020 | 24,447 | 13.2 | 322,556 |

Impacts of FLW on the environment has been reported. FLW contribute to 8% global GHG emissions (Vilariño, Franco and Quarrington, 2017). A study conducted by FAO, (2015) shows that approximately 25% of GHG emissions is produced at the post-harvest handling and storage although consumption stage was reported to produce the highest wastage and carbon footprint (FAO, 2015). Recent study shows about 56% of GHG emission was produced by 50% of avocado which was influenced by on-farm and consumer levels in Califonia (Qin and Horvath, 2021). Figure 2 shows how food supply chain contribute to carbon footprint and food wastage globally.

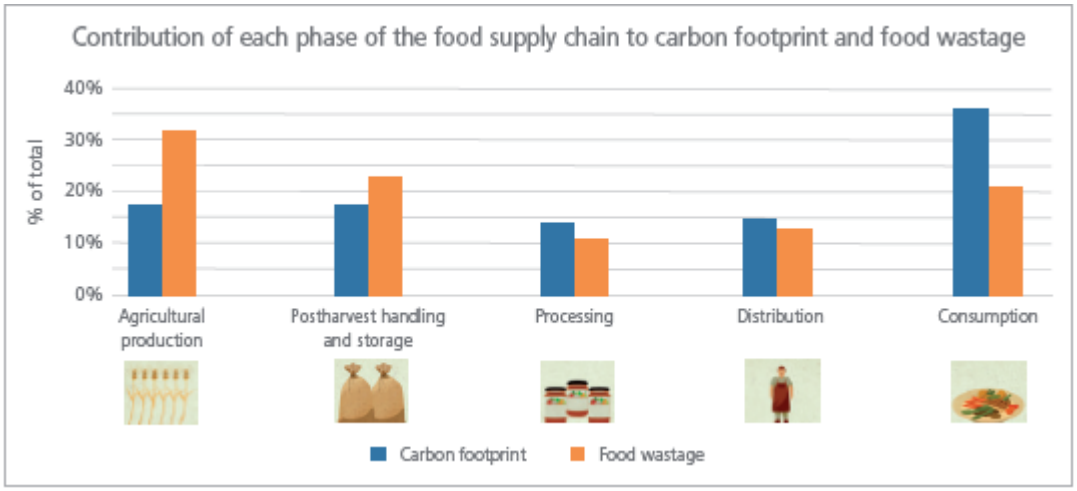



Figure 2: Contribution of food supply chain to carbon footprint and food wastage.

The UN General Assembly set the 2015 aim of halving food loss and waste in the food supply chain as part of the SDG 12 of responsible production and consumption to help reduce food loss and waste (UN, 2016). Scholars have highlighted several solution to reduce or rather prevent the FLW in food value chain as reviewed by Chauhan *et al.*, (2021). Further findings shows that solutions require participative approach they should be systematic (Strotmann *et al.*, 2017). Furthermore, they must meet FLW's social, environmental, and economic needs along the value chain (Alamar *et al.*,2018).

To come up with effective interventions to solve the existing FLW, it is important to identify leverage points along the specific value chain. Snel *et al.*, ( 2021) provides various leverage points which have different focus, scope, and scale. They include -

**Shallow leverage points:** Focus on the interventions that are easy to implement, and they consider addressing problems without modifying the entire system. This **e**ntails good agricultural practices and cooling storage

**Intermediate leverage points**: Include transport infrastructure, market access value addition and geoprocessing.

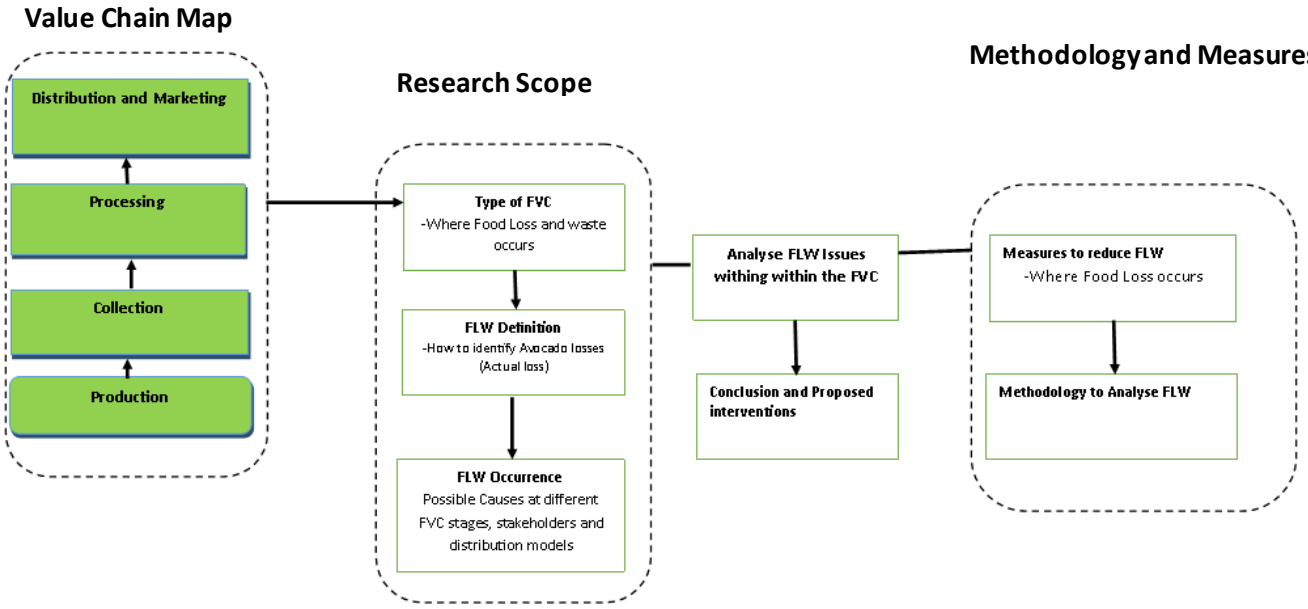
**Deep leverage points:** Concentrate on systematic adjustments to processes that are difficult to change but could result in transformational changes. It comprises creating favorable conditions and making investments that contribute to a more sustainable and inclusive food system**.**

Quantification of actual avocado losses in Kenya has been addressed in general (Snel *et al.*,2021). , however recent actual losses at the developing value chains need to be addressed. Quantification of FLW in avocado value chain is fundamental in influencing decision making and policies (Chauhan *et al.*, 2021). It enhances transparency and accountability in markets and support innovative technologies that alleviate the reduction of FLW (Redlingshöfer, Coudurier and Georget, 2017).

**Interventions:** According to Muth *et al.*, (2019) interventions are characterized as preventions, recovery or recycling which contributes to the Post-harvest losses/food losses and waste. Where prevention means source reduction, recovery corresponds to feeding hungry people and recycling is equal to industrial uses, feed animals and/or compositing.

## 2.2 Conceptual Framework

Conceptual framework provides an integrated approach of how research problem was be explored (Adom, Hussain and Joe, 2018). The general conceptual framework which will be applied in this study is based on a food loss and waste framework developed by Luo *et al.*, (2021). The framework guides in identifying food loss and waste problems within a food supply chain of value chain, it comprehensively helps to understand the critical points where these losses occurs and plausible causes along the value chain. Lastly it helps in analysing the issues and producing interventions to alleviate the food loss problems. Figure 3 provides a comprehensive conceptual framework applied in this study. A value chain concept will be integrated with a conceptual framework for identifying FLW in food supply chain according to Luo *et al.*, (2021).




*Source: (Luo et al., 2021) with modification*

*Figure 3: General Conceptual Framework.*

## 2.3 Definition of Concepts in FLW

**Food loss:** Is defined as measurable reduction in quantity or quality of food produce (FAO, 2018).

**Food waste:** Refers to discarded food meant for human consumption either before or after spoils (FAO, 2018).

**Flux-diagram**: As applied by FAO, (2018) is a flow diagram which provides visual sequence of product flow and underlying activities.

**Control loss points:** Theses are stages or level in avocado value chain where losses and waste are high which causes post-harvest losses (Snel *et al.*, 2021)

**Post-harvest losses**: These are losses that occur after the harvesting stage and all the steps in the value chain to the consumer level including farming practices, packaging, storage, transportation, processing, distribution, wholesale and retailing (Kitinoja, Tokala and Brondy, 2018).

**Pre-harvest loss:** These are losses that occur before harvesting level as a result of pest and diseases, natural calamities, weeds, rodents and birds (FAO, 2018).

**Post-production Loses:** Refers to the combination of both harvest and post-harvest losses (FAO, 2018).

**Post-harvest management:** The interconnected operations from harvest to crop processing, marketing, and consumer sale make up the postharvest chain. Postharvest Management is the whole of processes and measures that contribute to the flow of agricultural products (crops) that have been harvested or are suitable for harvesting (Gogh *et al.*, 2017).

**Value chain**: Is defined as all activities that are required to bring a product or service form conception through various stages of production, distribution to the consumer and final disposal (Kaplinsky and Morris, 2001).

**Food Supply chain:** Refers to agricultural supply chain consisting of only products intended for human consumption excluding non-food agricultural products

**Leverage points**: Snel, Broeze, and Kremer, (2021) describe leverage points as areas to intervene along the food supply chain to initiate appropriate interventions or changes. Leverage points are identified based on critical loss points.

# CHAPTER 3

## 3.0 Research Methodology

This section provides full description of methodology that was applied in this study which was purely applied research. It involved descriptive research design, sampling, data collecting instruments, gathering procedures and data analysis according to practical guide by Laws *et al.*,(2013), Consortium for Innovation in post-harvest loss & food waste Reduction, 2022) and FAO, (2022)

### 3.1 Study Area Description

This study was conducted in Nandi County, Kenya. The area is in the Rift Valley region of Kenya and occupies an area of about 2,884.4Km$^2$. The total population of Nandi is approximately 885,711 with women constituting to 50% while male 50 %. The county experiences cool and wet climate and experience two rain seasons annually ranging from 1200-2000mm with average temperature of between 15-25$^O$C (Kenya Meteorological Department, 2022). Nandi is considered ideal for avocado farming due to the cool climate complemented by rich volcanic soils. Main farming practices is subsistence and cash crop farming which involves crops and livestock keeping. Tea and avocado are produced as export cash crops to supplement household income (MoALFC, 2021). This study focuses on four main areas which include Kaptumo in Aldai subcounty, Emgwen and Lessos in Kapsabet subcounty, and Kaboi in Nandi South Subcounty.

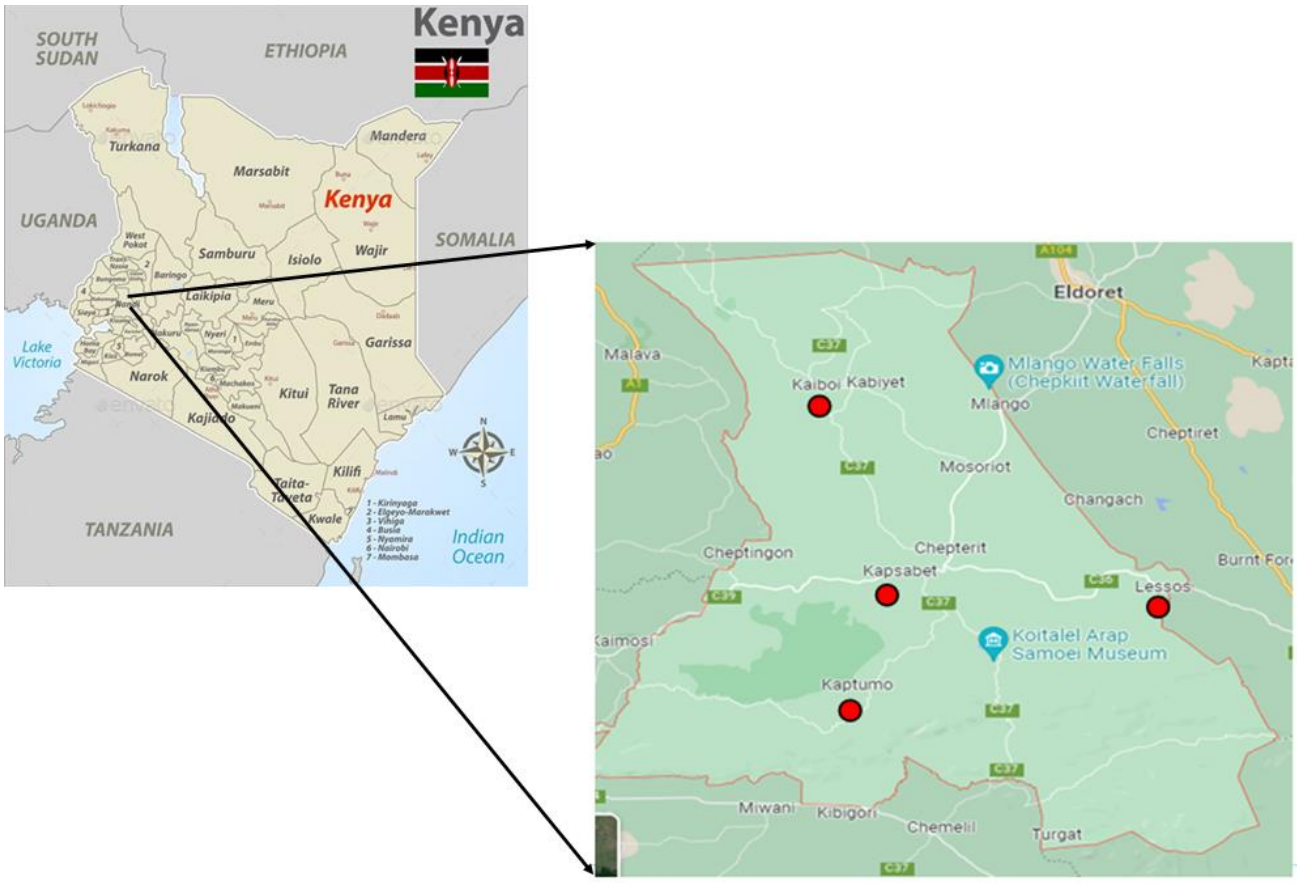



*Figure 4: Study Area Map*

Source: Google Maps, (2022)

## 3.2 Case Study Description

Nandi is among the county which has recently shifted from maize farming to avocado production. Most of the avocado produced are mainly in small scale of approximately 2,073 as of 2018 (HCD, 2019). Dominant growers are smallholder farmers who practice both subsistence farming and commercial farming for both local and export market. However, avocado production in Nandi is still low compared to other counties due to insufficient supply of quality planting material, low adoption to advanced farming technology and poor harvesting techniques (Mupeta, Mwasomola, and Haqbeen., 2022). Moreover, the subsectors face pest and diseases problem, poor postharvest management which affects the quality of avocado thus hindering cooperatives' bargaining power in export market (Research Solution Africa, 2015). Pests and diseases have posed a significant challenge to Nandi's small-scale farmers. Root rot (*Phytophthora cinnamomi*), anthrasnocephalus (*Colletotrichum gloeosporioides*) and Cercospora leaf spot (*Cercospora purpurea*) result to approximately 60% losses after long rain seasons (Kimaru, Muchemi and Mwangi, 2020).

Nandi Avocado Farmers' Cooperative Society was formed in 2019 to bring avocado farmers together, improving the current state and also enhance their bargaining power in the market. Currently, the cooperative has 1000 members with a total of 78 who have supplied avocados. The cooperative has so far partnered with the county government and two export companies (KEITT and Sunripe export company). As an initiative to help member farmers get to international market, a memorandum was signed between Sunripe Company Limited and Nandi Avocado Co-operative Society will produce and export fresh fruits. The deal provided farmers a chance to sell their produce at ksh.55(0.44 euro) for Fuerte variety and Ksh.80 (0.64 euros) for Hass avocado which is a standardized profitable rate (Sacco Review, 2021). Figure 1 shows the existing avocado value chain in Nandi County.

## 3.3 Description and Justification of the research methods

**Research Design**

Research design as explained partly in Figure 3 in this study was purely exploratory approach which aimed at finding information about actual state of avocado losses and waste and causes of these loses within the avocado value chain in Nandi as applied by Humble and Reneby, (2014). This approach is appropriate to this study since it aims at covering a continuous or a new phenomenon. A case study design was applied since it provides a holistic view of the Nandi avocado value chain, actors, and their links.

**The following methods were used:**

**Questionnaire Surveys:** Refers to a series of questions given to respondents to obtain statistical information regarding a specific topic (Roopa and Rani, 2012). Hard copy questionnaires were used in this study for smallholder farmers and answers later filled in google form, an online survey tool to ease analysis. The use of questionnaire was considered it is applicable to large sample size of respondents.

**Interviews:** Is where a series of question either structured or semi-structured are addressed to a responded are responses are recorded (Laws, Harper, and Jones., 2013). Interviews are mostly one on one with respondent. In this study, interviews were done both virtually and face to face with the respondents.

**Food flow diagram:** It is a flow diagram consisting all selected value chain links, their connections, with quantitative data on sales and residual flows (Wageninge University & Reaserch, 2020). In this study a value chain was used to illustrate product flows, actors, and food supply chain links.

**Declaration-based approach:** This approach is used in estimation of FLW based on the response of the farmer or other respondents in value/supply chain where they declare their losses as opposed to physical approach where estimates are based on physical measurement as described by FAO, (2018)

The main FLW assessment method involved rapid or initial assessment surveys to determine the critical loss points using purposive samples of the chain actors (Farmers, trader, wholesalers, retailers, processors, and exporters). The estimates mostly relied on subjective measurements (mostly from visuals or interviews) and objective measurements (data driven) which provides better understanding of post-harvest losses, the causes of these losses, critical loss point, effects on economic value and carbon footprint. Additional information such as conditions of operation of production such as climatic condition, farming systems was also included.

### 3.3 Description of data sources

In this study, both primary and secondary data sources were encompassed.

**Primary Sources** refers to first-hand information received directly from the source for example interviews and questionnaires (Asfaw, Geta and Fikadu, 2019). In this study primary data was acquired from the cooperative inventory, online speeches, respondents through semi-structured interviews and structured questionnaires, and photographs. The interview involved the main stakeholders of avocado value chain in Nandi through a selective approach which include Nandi County Avocado Cooperatives stafffs, traders, wholesalers, retailers, exporters, processors, consultants, officials from the ministry of agriculture and cooperative and KALRO officials while Questionnaire was used for producers.

**Secondary sources** refers to information acquired from existing literature both published and unpublished sources (Asfaw, Geta, and Fikadu 2019). Secondary sources used in this study include scientific journals, central such as KEBS, KALRO, FAO STAT, EURO.STAT, administrative records of the cooperatives, county government (Ministry of agriculture), and scholarly articles.

Triangulation was applied in this research which is described by Laws, Harper, and Jones., (2013) as using multiple methods and different methods and sources to increase the results confidence. To best understand the research problem, triangulation which involves parallel mixed-method research design was used as illustrated in figure 8.


*Figure 5: Triangulation*

Source: Laws, Harper, and Jones., (2013)

### 3.3.1 Overview of data sources and methods per research question

Table 2: Research Methods

| Research Question | Method | Tool | Output | Respondent/sources |
|---|---|---|---|---|
| **1a** | Application of Food flow diagram involving all selected chain actors | Questionnaire<br>Interviews checklist<br>Literature review | -Value chain Map<br>Quantitative detailed (sales, activities, quantity of the product flow, destination of residual flow) | Chain actors, chain facilitators and supporters within the Nandi value chain |
| 1b | Respondent declaration-based approach | Questionnaire<br>Interview checklist | Total loss produced at each value chain level (Harvesting, Collection, Transportation, Storage, Processing, Exporting) | Chain actors, chain facilitators and supporters within the Nandi value chain |

| | | | | |
|---|---|---|---|---|
| 2a | Interviews<br>Survey<br>Observation | Cause tree tool | Activities that lead to the Causes root of avocado losses and waste along the chain | Farmers<br>Traders<br>Processors<br>Wholesalers<br>Retailers<br>Exporters |
| 2b | Survey.<br>Interviews | Flux Diagram | Prioritizing the chain activities that are considered and areas with high losses | Table in output flow, information from all chain actors, facilitators, and supporters |
| 3a | Interviews<br>Surveys | Calculations based on quality and values | Economic effects to be identified | Farmers (40)<br>Traders (3)<br>Processors (2)<br>Wholesalers (1)<br>Retailers (3) |
| 3b | Conversion of waste produced to Carbon equivalent | Carbon equivalence calculator | Total carbon emissions from the waste | Total waste produced at each value chain level |

### 3.4 Description and Justification of sampling methods

Information related to avocado losses and waste were obtained through integration of both qualitative and quantitative samples. In this study purposive sampling was used to choose the interviewers (respondents). Purposive sampling is a non-probability sampling strategy in which participants are chosen based on the study's objectives in order to acquire relevant data (Laws, Harper and Jones., 2013). Only responded related to avocado value chain were interviews. Random sampling was applied based when choosing four sampling areas from the existing six on assumption that the samples they have the same climatic conditions have typical problems in avocado value chain. From each area, section for data collection was selected based on snowball sampling since most of the farmers are scattered. A total of 40 farmers were selected to fill questionnaires in Aldai, Emgwen, Kiboi and Lessos. Other actors such as the traders (3), processors/exporters (2), wholesalers (1), retailers (3), and other external actors were selected purposively considering their direct involvement in the current avocado value chain and they were interviewed. Two respondents from cooperative and other external actors were selected mainly the head officials.

## 3.5. Data Analysis Plan

The first phase of data analysis involved compiling the results which include field notes from interviews and surveys. Questionnaires had codes for ease of reference. This research included both qualitative and quantitative analyses. Standard programs like Microsoft excel and Microsoft word was used for basic analysis qualitative and quantitative data. They were used to order of copy texts, prepare diagrams and compare figures.

The expected results were converted into two data set as illustrated in figure 6. The design which involved the value chain concept comprehensively provided the analysis of the avocado losses and waste among smallholder farmers chain, as well as giving leads to appropriate interventions along the value chain.

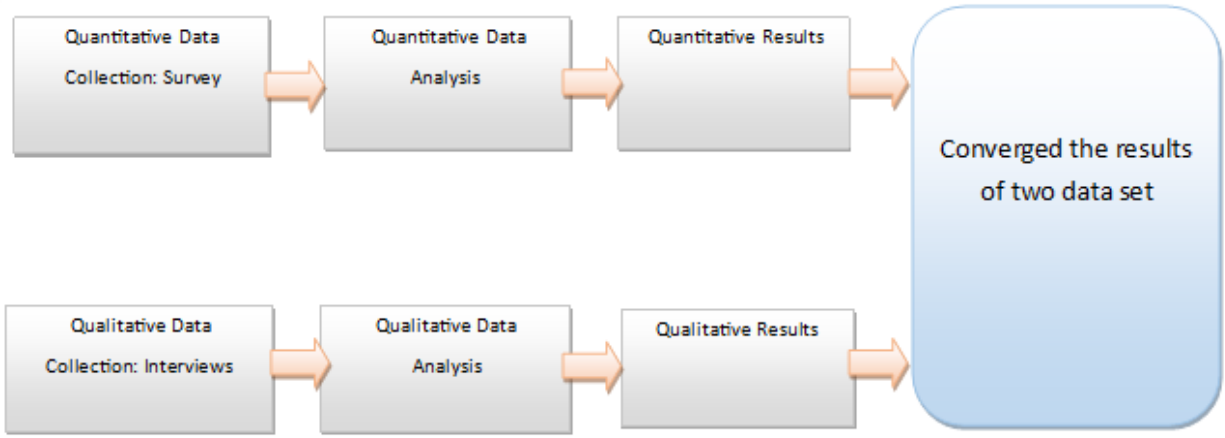



*Figure 6: Research Design*

Source: Anoba and Cahapay, (2020)

### 3.5.1 Qualitative Analysis

To analyse qualitative data preliminary list of categories from interviews and questionnaires were used and set in a clear format. The categories included the key points such as level of education, availability of extension, gender, number of trees, quantity of avocado produced, transportation system, packaging system, buyers of avocado, price information, storage are causes of losses/rejection, quantity of avocado that get spoiled, management of avocado waste and avocado quantity sold in the year 2021-2022. Setting up the categories helped to create links which enable answer the research questions. Frequency table was used to determine selling channels of the smallholder farmers.

### 3.5.2 Quantitative Analysis

Quantitative data was analysed through descriptive statistics using SPSS where central tendencies were measured such as means, frequencies and percentages. One sample t-test was used to compare differences in losses among the farmers significantly at 0.05. At the production and collection stages actual data were used to determine avocado losses while the processing, distribution and consumer level percentage estimation from FAO, (2011). Where processing loss is estimated at 25%, distribution 17% and consumption 5% respectively. Quantification of the FLW was done using simple formular according to United Nations,(2020) as shown below;

***Farm Level***

X (Kg) Expected Harvest – X (Kg) Actually Harvested= Food Loss I (Kg)

The expected harvest was calculated as production per tree per year where 3-4 year old tree produces approximately 230kg of avocado per year according to KALRO, (2018)

***Collection Level***

X (Kg) Actual harvest –X (Kg) collected produce= Food Loss II (Kg)

***Processing and Packaging***

25% of the collected produce at Collection level=Food Loss II (Kg)

***Distribution***

17% of the collected at the processing and Packaging=Food Loss (Kg)

***Consumption***

5% of the collection at the distribution level=Food Loss (Kg)

Results from calculation were analyzed using Microsoft excel to determine the FLW and percentages at each value chain level. Effects on carbon footprint was based on calculating the carbon emission of the quantity of waste produce based on carbon equivalence using carbon footprint calculator Watch my waste, (2022). 1.9 Carbon dioxide equivalents per kg of food waste (kg $CO_2e$ FW) was used to calculate GHG emissions produced at each individual value chain level. A descriptive analysis was done using value chain approach to estimate effect of FLW on economic value along the chain. Mean selling prices at each value chain was used and multiplied by the total losses at each level Quantification to get the economic value as described by (Snel et al., 2018). PHL was based on total amount of avocado that do not end up on the consumer while overall FLW was calculated from the Farm level to consumer level.

# CHAPTER 4

## 4.0 Results

In this chapter, the empirical results are presented and divided in to three sections; the current value chain and estimated loss and waste, causes of FLW and critical loss point, effects of FLW on economic value and carbon footprint.

## 4.1. The current value chain and estimated loss and waste

This section illustrates insight of the current state of avocado value chain in Nandi and the estimated amount of FLW with the chain. The results originate from interviews, surveys and existing literature that was undertaken in Nandi.

### 4.1.1 Avocado value chain In Nandi

The product flow in Nandi avocado chain end to the consumers through various channels. The export market seems slightly clear where the buyers and traders such as the cooperative and export company are well connected and transparent. Brokers and traders form an informal channel where they determine prices. The chain has many loops and actors from the production to the market. Majority of the smallholder farmers (60%) are members of the cooperative which act as a market link between farmers and the exporters. Both farmers who are members (60%) and non-members (40%) sell their produce through the cooperative. However, about 36% of the smallholder farmers who are members of cooperative are unsatisfied with the cooperative as indicated in Annex 7. Majority of the producers use less advanced technology in production and harvesting. Transportation is done through open pickups at times motorbikes where avocado arranged on the first layers are exposed to direct sunlight. Transportation to the export companies is by lorries which lack cooling system. The cooperative has partnered with only two exporting companies KEITT and Sunripe exporting company. Additionally, the cooperative has also partnered with the county government which provided technical supports and help connecting the cooperative with export companies.

Figure 7 illustrates the value chain map of both domestic and export market of avocado.

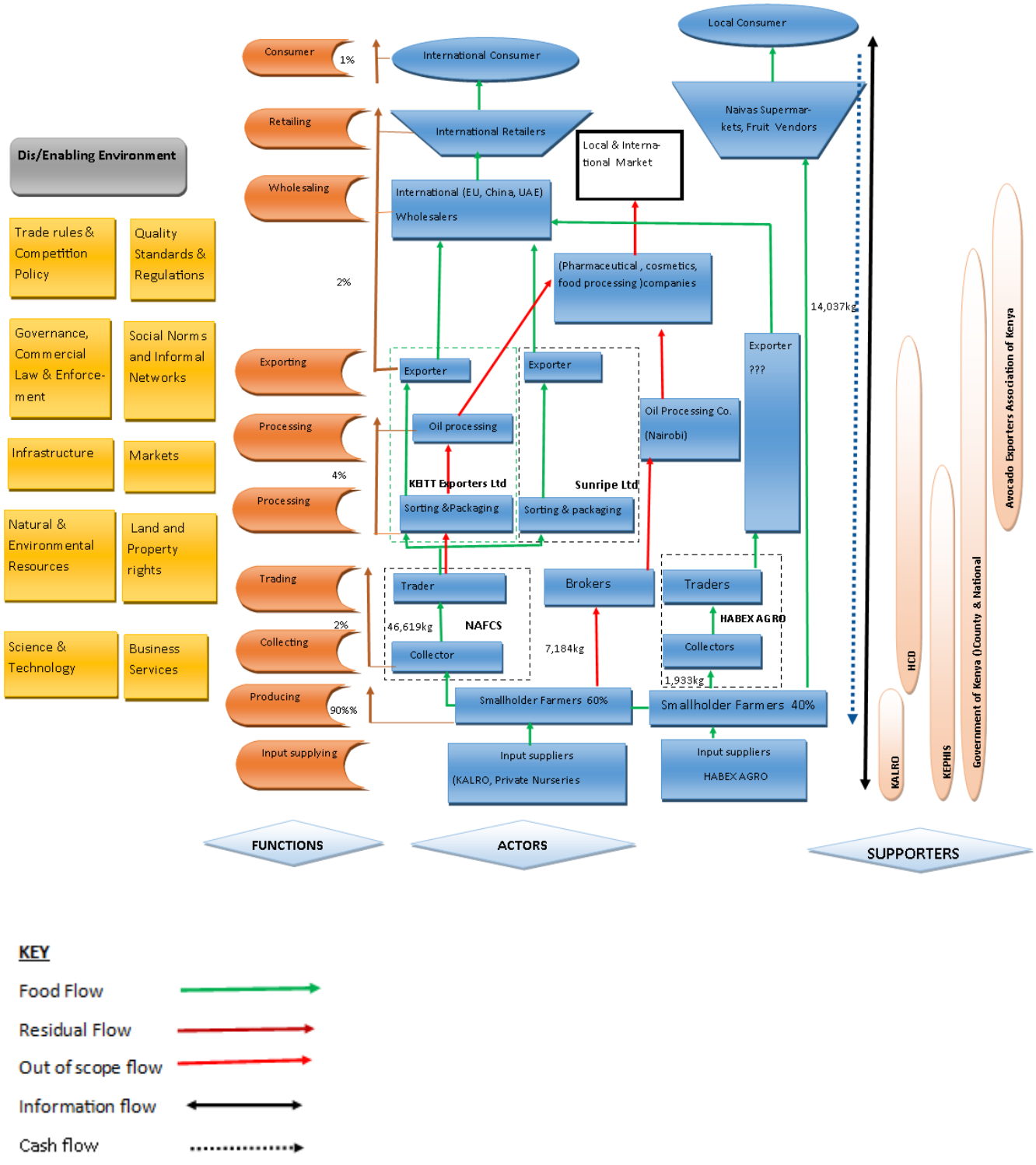



Figure 7: Current Avocado Value Chain in Nandi

Farmers in Nandi sell their avocado to more than one buyer. However, most farmers sell their avocado at the cooperative only which recorded higher percentage frequency of over 48% while those selling at both the cooperative and the retailer had the least frequency of 3%. Table 3 shows the selling channels between farmers and buyers in Nandi.

Table 3: Selling Channels of avocado from Smallholder in Nandi

| Buyers | Frequency | Percent |
|---|---|---|
| Cooperative | 19 | 47.5 |
| Brokers & Traders | 8 | 20.0 |
| Cooperative & Brokers | 7 | 17.5 |
| Traders | 3 | 7.5 |
| Brokers | 2 | 5.0 |
| Cooperative & Retailers | 1 | 2.5 |
| **Total** | 40 | 100.0 |

### 4.1.2 Estimated Food Loss and Waste

Data from Interviews and questionnaires were obtained from the cooperative, and the farmers from Emgwen, Nandi Hills, Kaboi and Lessos. The collection samples from the study areas were not equally distributed hence no comparison was made. The overall FLW was estimated at 343,412kg/year. Production stage recorded highest percentage losses of about 90% followed by collection and storage (2%), processing (4%), distribution (2%) and consumption (1%) respectively. Comparison of the losses at both export and domestic market is not presented due to insufficient data in the domestic chain. Table 4 summarises the key results for the period between April and August 2022.

Table 4: Calculated food loss and waste in Avocado value chain

| Value Chain Stages | Actual FLW (Kg) | |
|---|---|---|
| Production | 309,957 | Losses |
| Storage and Collection | 8,341 | |
| Processing and Packaging | 15,365 | |
| Distribution | 7,836 | Waste |
| Consumption | 1,913 | |
| **Total FLW** | 343,412 | |

The total quantity of avocado harvested in Nandi is 69,773 kgs/year from farmers in Emgwen, Nandi Hills, Kaboi and Lessos between April to August. PHL which represented avocados losses after harvest

to distribution level was estimated at 31,542kg/year which is about 45%. Total quantity that reaches the consumer level is 38,231 kg/year which is approximately 55% of the total quantity harvested as shown in table 5.

Table 5: Distribution of volumes at the harvesting stage and PHL

| Quantity Harvested (Kg/year) | Quantity Sold (Kg) | Post-Harvest Losses (Kg) |
|---|---|---|
| 69,773 | 38,231 | 31,542 |

Figure 8 shows proportion of PHL in Post-harvest chain in Nandi. The PHL was approximately 45% of the total avocado harvested. Processing and packaging produced highest losses estimated at 49% of the total post-harvest losses.

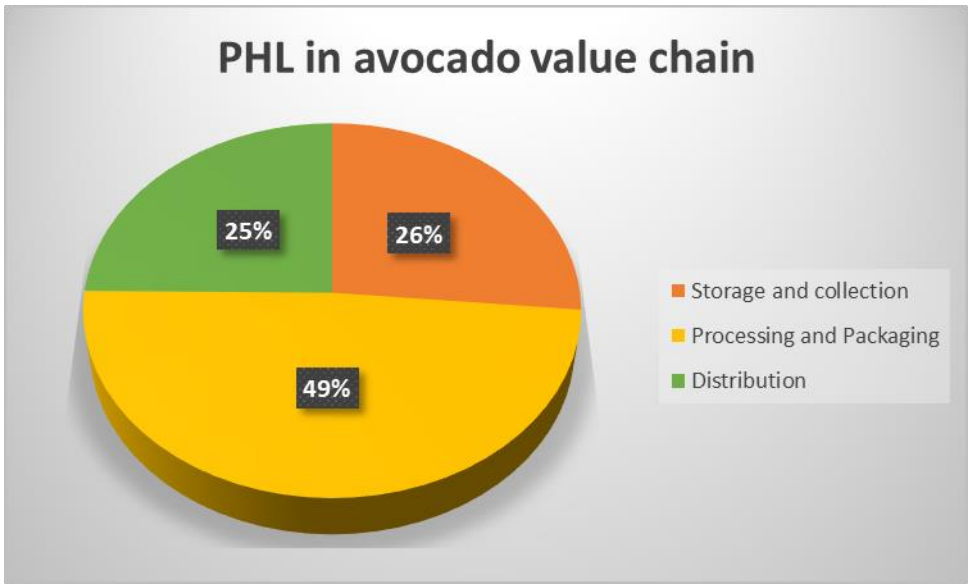



Figure 8: post-harvest losses in avocado value chain

Figure 9 shows percentage FLW at each level in avocado value chain in Nandi. Production level recorded the highest percentage of losses at 90% while consumption level had the least percentage 1%.

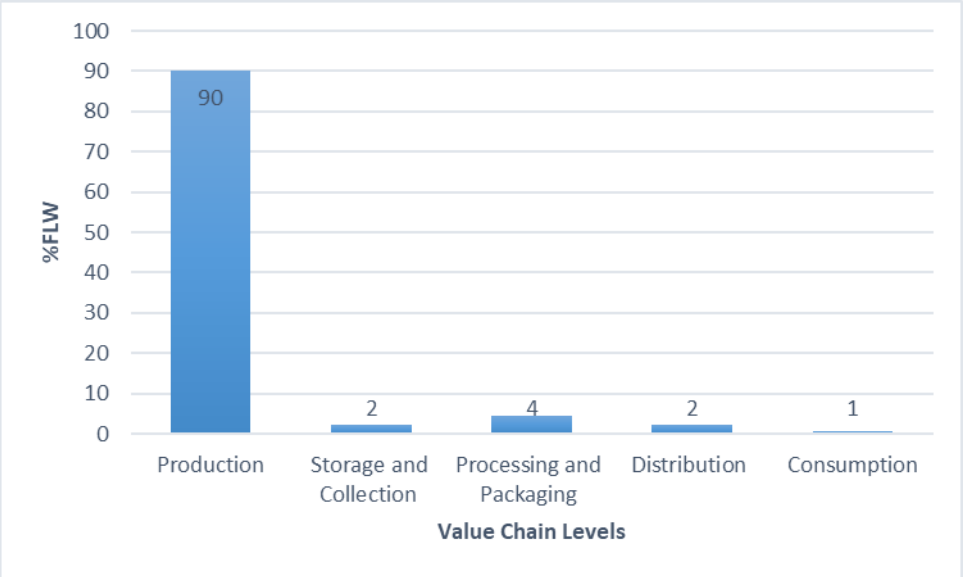



Figure 9: Overall FLW in Nandi avocado value chain

The avocado being bought by the cooperative are collected at the collection centre within the village which are in the same spot where tea is being collected while others are collected directly from the farmers homestead. Total quantity of FLW among 40 farmers was at a mean of 8328kg/year as shown in the table 6 bellow.

Table 6: Total Quantity of FLW in Nandi

| | Valid N | Mean Losses | Minimum | Maximum | SD |
|---|---|---|---|---|---|
| **Total Quantities Losses (Kgs)** | 40 | 8328 | 4872 | 11783 | 10804.78 |

## 4.2 Causes of FLW and mitigation areas

### 4.2.1 Causes of FLW in avocado value chain

The output of this section was from the interviews and questionnaires in addition to the observations made during the field studies. Figure 10 illustrate causes of food losses at the production level. All respondents reported to have experiences losses. The major cause was environmental factors which represent drought, hailstones, pest and diseases, and premature dropping of the fruit with percentage response of 48%. Harvesting techniques and social factors (theft) had the least response at 7%.

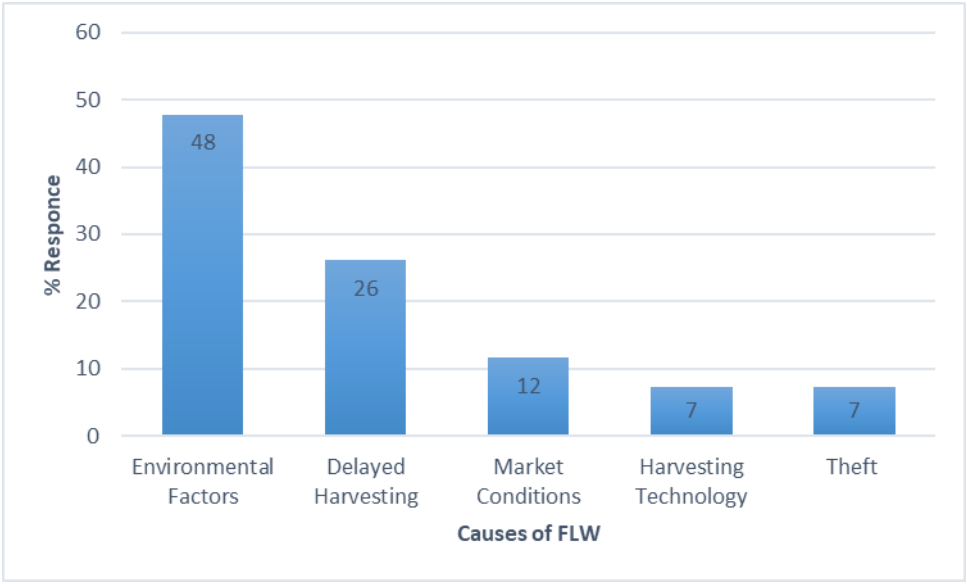



Figure 10: Causes of FLW at the production (On-farm) level

Over 35 smallholder farmers reported that most of their produce are rejected by the cooperative due to Physical damage. None of the respondents reported issues of dry matter among the major cause of the rejection as presented in figure 11.

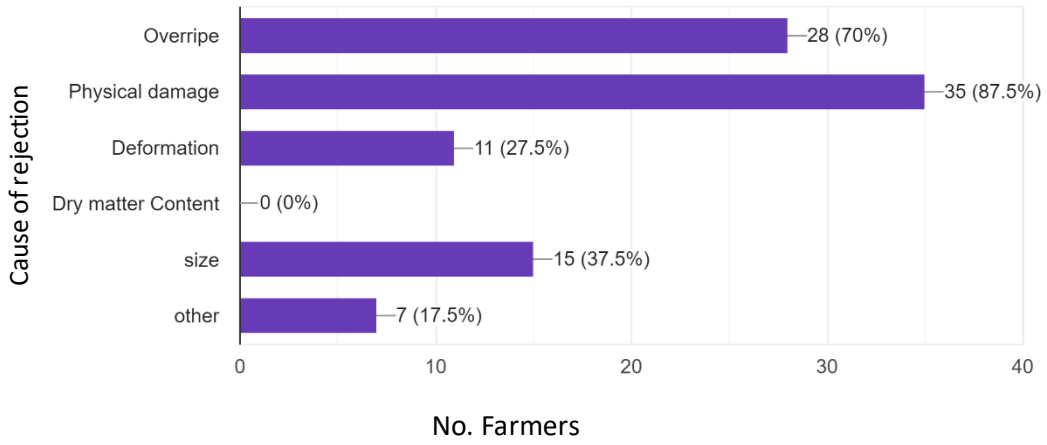



Figure 11:Causes of FLW at the Collection Centre

Identification of the root causes of avocado loss at the production level using cause tree tool presented in Annex 8. Some of the main causes mentioned by the respondents including premature fruit dropping, delayed harvest, pest and diseases, and drought are linked to poor agricultural practices, market inaccessibility, and poor infrastructures among others as indicated in table 7. Most farmers are experiencing losses because of drought since most of them do not own irrigation systems. Post-harvest levels such as collection, processing, and distribution experience FLW because of bulk loading, poor transport and packaging as indicated in Table 8. Some actors such as the cooperative lack storage facilities hence most of delayed harvest are usually stored by farmers in tradition techniques which include leaving the harvested avocado under the shade and sprinkle water until they are collected.

Table 7:Root causes of FLW at the production level in Nandi avocado chain.

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

Table 8:Root Causes of FLW at the post-harvest levels in Nandi avocado chain.

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

### 4.2.2 Critical Loss points in the avocado value chain in Nandi

The following section describes the stages in avocado value chain in Nandi where losses are high and the main causes. Losses at the production level were significantly high compared to the post-harvest losses at the collection, processing, and distribution levels. Majority of the farmers experience losses at the farm, during harvesting, storage after harvesting and during transportation to the collection centres. Farmers in Nandi practice mixed farming which involve tea, coffee and other stapple food such as maize, banana, and beans. Additionally, most farmers only harvest once a year during the peak season between March to September while during the low season (October -February) most farmers remove the young fruits as illustrated on Figure 13 and halt second production due to lack of market. The cooperative hardly buys avocado during off-peak season. Critical loss points lead to identification of leverage points as indicated in Annex 13. Figure 12 shows critical points in Avocado value chain in Nandi.


Figure 12:Flux Diagram and Critical Loss Points for Avocado in Nandi

Figure 13:Thinned avocados during off peak season

Figure 14 shows that majority of the farmers about 43% use sacks to empty their produce after harvest for marketing while 35% use buckets, 15% places the avocado on the ground after harvest and only 8% use crates.

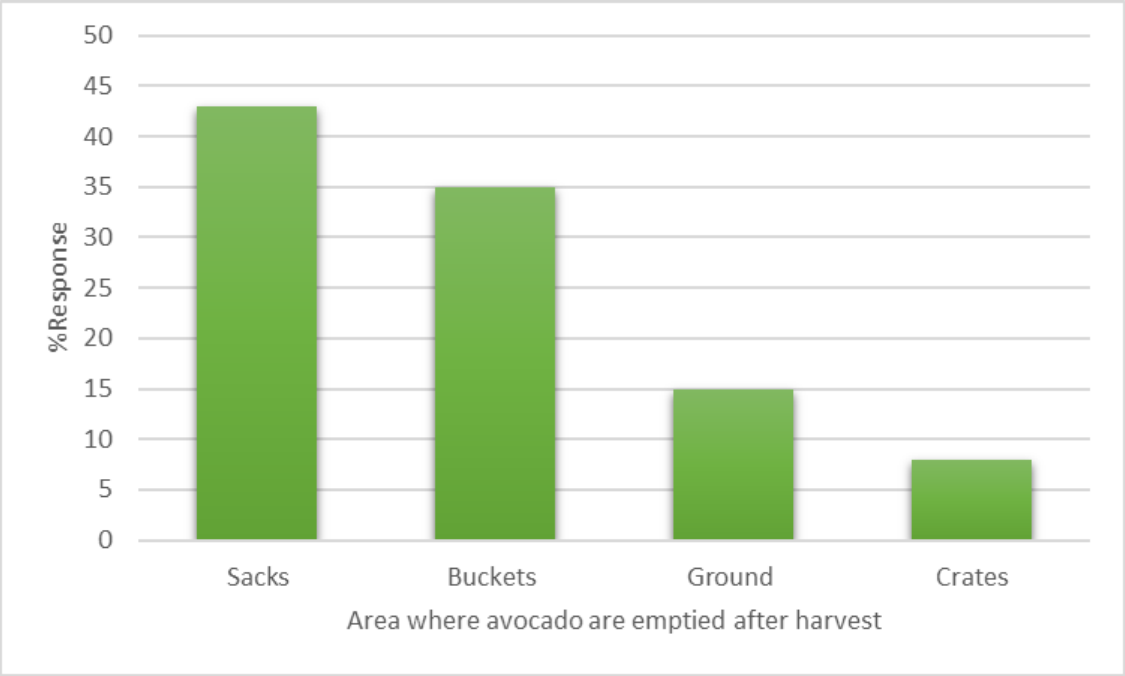



Figure 14: Where farmers empty avocado after harvest

## 4.3 Economic effect and carbon footprint of FLW

### 4.3.1 Effects on economic value

The economic value of FLW within the avocado value chain of Nandi is presented in table 9. The total losses presented between April and August 2022 was KES 33,131,886. Producers lost an average of 341,566kgs which is equivalent to KES 16,970,146. The cooperative presented the least economic value of KES.750,690 equivalent to 2 % as presented in table 9 and figure 15.

Table 9:Effect of FLW on economic value

| Value Chain Stages | Total Loss (Kg) | Average Price (Ksh) | Economic value (Ksh) |
|---|---|---|---|
| Production | 309,957 | 54.75 | 16,970,146 |
| Storage & Collection | 8341 | 90 | 750,690 |
| Processing | 15365 | 850 | 13,060,250 |
| Distribution | 7836 | 300 | 2,350,800 |
| **Total** | | | **33,131,886** |

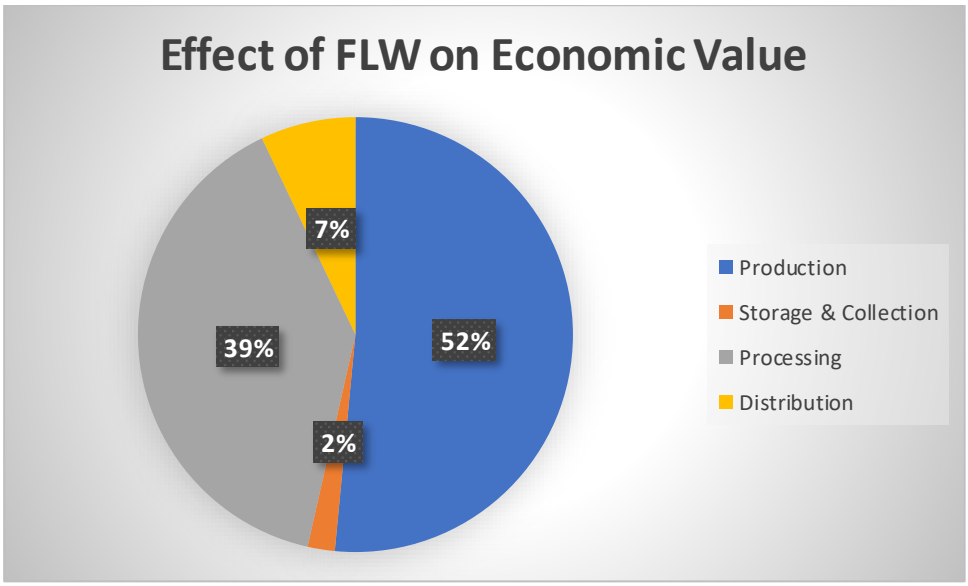



Figure 15: Percentage economic value of FLW

### 4.3.2 Effects on carbon footprint

Table 10 summarises the total quantity of carbon emission produced from the waste in Nandi Avocado chain. Production level of the value records the highest carbon equivalence per kilogram of 648975. $CO_2$-e/kg which accounts to 90% since it produces large quantity of avocado waste while consumption level produces the least waste hence little amount of carbon footprint is recorded as illustrated in figure 16. Table 10 shows total amount of emission in carbon equivalence produced in each value chain stages.

Table 10: Carbon Footprint of FLW

| Value Chain Stages | Waste (Kg) | Emission of CO2-e /kg | Total Emission (CO2-e/kg) | Percentage Emission |
|---|---|---|---|---|
| Production | 309,957 | | 588918 | 90 |
| Storage & Collection | 8341 | | 15848 | 2 |
| Processing | 15365 | | 29194 | 5 |
| Distribution | 7836 | | 14888 | 2 |
| Consumption | 1913 | 1.9 | 3635 | 1 |
| **Total** | **343,412** | | 652483 | |

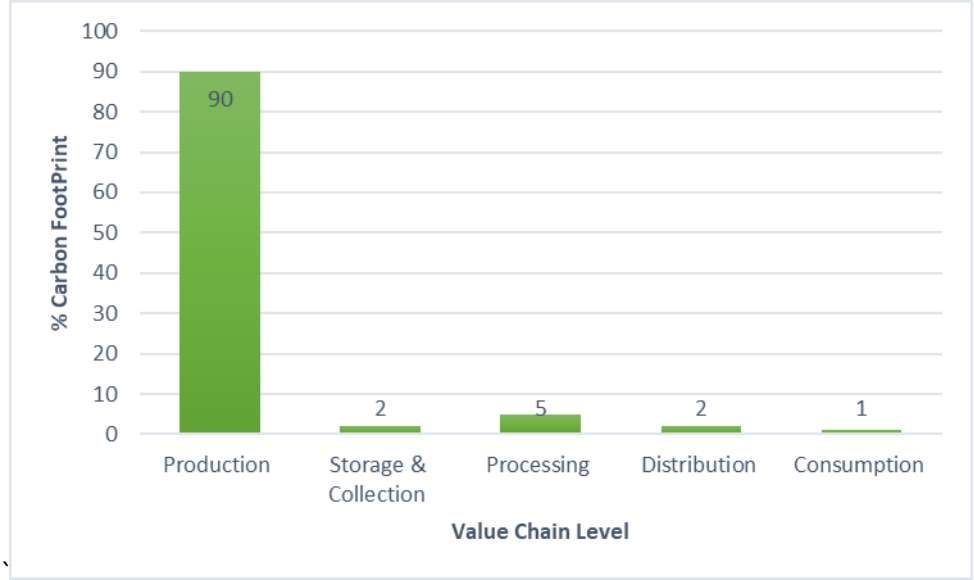



Figure 16: Percentage carbon footprint

### 4.3.3 Management of rejects along the value chain stages

Rejected avocado at the collection centres or selling points are mostly used for home consumption. Less spoilt ones are given to animals while completely spoils ones are disposed in farms as manure. Figure 17 illustrates frequencies of how farmers manage avocado rejects. Based on the Key informants Sunripe Export limited avocado that fail to reach export requirements are sold to avocado processing companies while completely spoiled ones are disposed in pits or landfills.

KEITT Exporters Limited buys both grades from the cooperates hence no rejects are returned to the farmers. The company has oil processing plants where grade two (G2) avocados are use while grade one(G1) are exported. By-products from oil processing are then used to produce animal feeds.

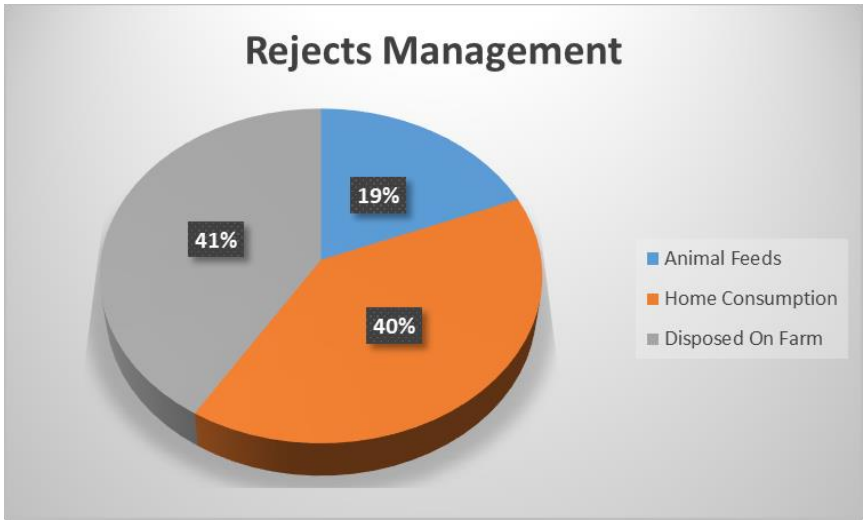



Figure 17:Management of rejects along the value chain stages

# CHAPTER 5

## 5.0 Discussion

### 5.1: Estimation of FLW in avocado value chain in Nandi.

#### 5.1.1: Current Value Chain

The avocado value chain presented in this study can mostly be described as a B-system in Trienekens, (2011). The system is characterized as low to high income chain. The Nandi producers aim at supermarkets and export markets. There is only one existing formal horizontal relationship where 60% of the producers are organized in cooperative while 40% were in a vertical relationship where they were initially linked to subcontracting arrangement with HABEX Agro limited. Most of the avocados are delivered to the market by the cooperative although other market systems include brokers and traders. Few producers interviewed sell directly to the retailers such as the supermarkets. This suits well with B-system type of value chain described by Trienekens, (2011). Few of the respondents sell their produce to local markets which can be described as A-system. However, A-system is purely characterized as the low-income chain focusing only on local markets for staple products(Trienekens, 2011). Moreover, the C-system value chain is for export chain which cannot be the case in this study.

According to the key informant in this study, the local value chain is dominated by local varieties which are mostly preferred by the locals because of their big sizes. However, majority of the producers interviewed have focused on hass, fuerte and other varieties meant for export market but not all end up in the export markets but very few getting into domestic retailers. Comparing FLW for each actor in both domestic and export market was not achieved. This is due to complex distribution networks that involves the cooperative, and informal linkages like traders, and brokers hence no reliable losses could be recorded. The cooperative only has two export companies KEITT and Sunripe but are not reliable due to delay in collection. According to the key informant, cooperatives are restricted by HCD from selling avocado to more companies hence limited market for avocado farmers in Nandi. Moreover, the cooperative has limited partnership with only two export companies, and the county government. According to Bustos Moors and Hellen, (2018) interorganizational relationship is important for effective partnership as it brings about information exchange improve technology application and align incentives. This innovative collaboration has enhanced reduction of PHL hence improve chain reliability.

The cooperative has influenced negotiation of better prices (KES. 67-100/kg) for farmers compared to the informal chain. Between 20-24% of the smallholder farmers in Nandi are satisfied with cooperative since it has provided them with markets and better prices. About 36% are unsatisfied due to delayed collection, poor coordination and service provided are only limited to market provision. Moreover, there is limited information flow regarding prices, markets availability and some farmers claiming the payment methods are not transparent thus affecting the chain robustness. This is reflected in a study conducted by Kenya Human Rights Commission, (2015) regarding the effectiveness of agricultural cooperatives, showing that most farmers have lost confidence in cooperatives. This is due to poor governance structure within the cooperative.

Smallholder farmers sell their avocado produce to multiple buyers due to unreliable market from the cooperative. Traders and brokers control the market price where avocado is sold as low as KES. 30-40/kg and product avocado quality standards is only limited to physical appearance. The existence of such value chain links pose a challenge in harmonizing the quality and safety standard in avocado

value chain (Trienekens, 2011; Devaux *et al.*, 2018). Limited information system , together with brokers limiting information flow, and the market level orientation (KIT, MaLi and IIRR, 2010) in avocado value chain, hence FLW within the chain can be assumed low.

### 5.1.2 Quantity of avocado FLW

The results from this study presents FLW where losses estimates were from the farm to the processing and packaging stage while losses that occur at the distribution level are considered 'food waste' because are grouped as intentional losses as described by (FAO, 2018). Overall FLW was approximately 343,412 kg/year estimated form the on-farm to consumer level. About 309,957kg/year losses are incurred at the production mainly on-farm which accounts to 90% of the overall FLW. This findings coincide with the study by Johnson *et al.*, (2018) where 65% of unharvested crops which were of edible quality remained in the field. Based on the interviews and survey, major contributing factors include market dynamics during off peak and peak season, and environmental factors. Previous studies shows that most of on-farm losses are beyond producers' control which include low market prices, pest and diseases (Campbell and Munden-Dixon, 2018;Johnson *et al.*, 2018).

The post-harvest losses were estimated at 45% which accounts to FLW produced at the collection point after harvest and before it reaches the consumer level. Processing and Packaging had the highest portion losses estimated at 49% of the total PHL followed by storage and collection at 26% and distribution was the least with 25%. Results from this studies were similar to FAO, (2018) and Snel *et al.*, 2018) where PHL at processing and packaging were reported high in fruits and vegetables. A lot of rejects are produced at the post-harvest chain because of overripe, physical damage or issues related to dry matter content. Based on the survey there is no cooling storage, hence farmers harvest their produce either in the morning or a day before collections by the cooperative or traders and this affect the quality at a later stage of value chain. Currently, there is no aggregation centres in Nandi but collection points which are used for both tea producers and avocado. According to Snel *et al.*, (2021) lack of cold storage at the local aggregation centre contribute substantial to PHL.

Additionally, results from the studies shows that the root causes of these losses are attributed to bulk packaging which results to mechanical damage. Major drivers of losses at the processing and packaging are caused by physical damages acquired during transportation and damages due to secondary infections (Mysore, and Gajanan 2011). According to FAO, (2011) losses occurring at the processing and packaging are caused by spoilage down the production level and errors during the processing that results to products with damages and appearance. Estimated losses which is termed as waste at the distribution level (Export, wholesale, retailing) was approximately 25% of the total PHL which is associated with poor packaging and bulk transport.

## 5.2 Causes of FLW and Critical loss points

### 5.2.1 Causes of FLW in avocado value chain in Nandi

Findings from this study indicate that most losses occurring at the farm level are due to environmental factors with a total response at 48%. These factors include drought, premature dropping of fruits(senescence), hailstones, pest, and diseases. Other factors noted were poor harvesting techniques especially for trees that have overgrown which makes it difficult for farmers to harvest the avocadoes. Market conditions related to accessibility of markets; fluctuation of markets prices has resulted to major losses since some farmers opt not to sell their produce. Additionally, the issue of markets inaccessibility results to delayed harvest thus most produce remain unharvested. According

to Campbell and Munden-Dixon,( 2018) most of the drivers of FLW at farm level like market dynamics, weather and pests are beyond farmers' control. Subsequently, the interaction of these factors results to complexity which makes it difficult to calculate and reduce food loss at on-farm level. Some other factors based on observations and interviews include infrastructure such as inaccessible roads where most areas are completely inaccessible by car/lorries making it difficult for the cooperative to collect avocados.

Losses at the collection point were associated to physical damages, overripe, deformation, and sizes. Physical damages are associated to poor harvesting techniques, poor packaging, and bulk transportation. Majority of farmers in Nandi approximately 43% use sacks to package their produce to collection centres or markets. Furthermore, lack of storage facility in Nandi contributes major losses as famers have to wait for a day or two for their produce to be collected. Mendieta *et al.*, (2016) opines that proper pre-conditioning not only delays avocado ripening but also increase the shelf life which is important for export market. The cooperative depends on the export companies to transport their produce to Nairobi which sometimes delay harvest and late collection hence contributing substantial number of losses both at the production level and subsequent value chain stages.

In this study, losses at the processing level of the value chain are attributed to bulk loading, poor quality of avocado, poor handling during packaging and transportation. Results from observation shows that lorries being used for transportation lack cooling storage this enhance quick ripening before the avocado even reach the distribution level. This increases the possibilities of most avocado not ending up to the consumer level explaining high percentage of losses. Previous research based on FAO, (2018) indicate that processing and packaging record highest percentage of losses in fruits and vegetable chain whose root cause are linked to food safety standards and quality. Moreover, less application of standard procedures on checking the quality of avocado at the collection centre such as checking dry matter content and chemical residue contribute to high percentage of rejects at the later stages of the value chain. Mendieta *et al.*, (2016) states that cold damage and quality reduction in avocado can be prevented if the dry matter is 22.9-26.3%.

Low demand of Hass avocado at the local markets has contributed to losses at the supermarket in Nandu since the most people prefer local varieties which are bigger in size compared to Hass and Fuerte. Most of this supermarket have cold storage with alternative power source hence losses are not associated with storage issues. Consumer level recorded the least loss whose contributing factors are linked to consumer attitude as some purchase more than they can eat.

### 5.2.1 Critical loss points in avocado value chain

In this study, identification of critical loss points was based on value chain levels which experience high level of FLW and underlying activities. A greater proportion was recorded at the production level (90%), processing and packaging (4%). Result presented on the flux diagram shows pre-harvest stage and harvest stage as a major control loss point at the farm level, storage is also done at the farm level since there is no aggregation structure in Nandi. Traditional methods of storage include watering during the day and leaving them outside at night. Packaging and transportation to collection points, transportation to processing and packaging companies in Nairobi were also Identified as critical points contributing to FLW. Identification of Critical loss points is important as it helps in determining leverage points that helps to bring desired changes to reduce FLW ( Snel *et al.,* 2021).

## 5.3 Effect on economic vale and carbon footprint of FLW

### 5.3.1 Effect of FLW on economic value of avocado value chain in Nandi

Avocado is an important commodity in Kenya contributing to 74% of fruits export by value (Muriithi and Kabubo-Mariara, 2021). Results from these studies uncovers how FLW affects different stakeholders along the value chain levels. Production level recorded the highest potion at 52% followed by processing at the 39%. Most of the farmers interviewed solely depends on farming for their livelihoods hence losses in avocado value chain denies them this benefits since most of them had shifted from maize farming to avocado farming. According to the report by IARD, (2017) reducing losses without additional resources has a potential of improving livelihoods. Moreover economic effects not only affects the farmers but all the stakeholders in the chain including the government where huge amount of revenue occurs as explained by Snel *et al*., (2021).

### 5.3.2 Effects of FLW in Nandi avocado value chain on carbon footprint

One of the environmental effects of food waste include increase in carbon emissions (Eriksson, Strid and Hansson, 2015). In this study, 652,482.8 CO2-e/kg **is** produced from the waste incurred from the production to consumer level. Majority of the respondents accounting to 41% dispose their rejected produce at the farm. Waste management at the distribution level involves disposal of avocado waste in the landfills or pits. According to Gillman, Campbell and Spang, (2019) organic matter from food waste produce methane which is considered to be greater at 25 times more potent than carbon dioxide. FAO, (2011) opines that most industries believes that disposing is cheaper that reusing or using food waste which is the case in this study. Very few processing company such as KEITT present a proper way of managing low quality avocado which include processing oil. Remains from processing are then sold to animal feeds company for further processing.

## 5.4 Research Project Limitations/Reflection

The main limiting factors in this study insufficient reliable data from majority actors of the avocado value chain in Nandi. Majority of farmers did not have inventories regarding the cost of production hence difficult to calculate economic loss at the farm level. Moreover, they lacked inventories of the total quantities they sell hence losses relied largely on percentage estimates from the existing literature. Most traders and processing companies had a closed attitude which is due to fear of competition thus they were not ready to provide exact figures of losses and waste.

Additionally, the avocado value chain was complex and unstructured with too many linkages hence difficult to assess food losses at an actor level. Various methods which were earlier proposed had to be changed particularly sampling areas. Farmers are not equally distributed in the study area hence difficult to make comparisons.

# CHAPTER 6

## 6.0 Conclusion and Recommendations

### 6.1 Conclusion

The value chain presented in this study is a B-system type of value chain since producers sell their avocado produce to both domestic and export markets. The chain has one formal horizontal relationship where majority of farmers are organized in a cooperative. No value addition takes places from the farm level to the trading level of the value chain. Majority of the farmers have more than one buyer since there's poor coordination between the cooperative and the farmers in addition to lack of ready market to their produce. Many informal linkages bring about complexity hindering traceability and maintaining the quality of avocado.

Total avocado FLW is estimated at 343,412 kg/year which is inclusive of on-farm losses to the consumer level. The post-harvest losses were estimated at 45% of the total harvest which did not reach the consumer level. Processing and packaging level estimated the highest percentage loss compared to other value chain level (collection and distribution level). The production level which included On-farm losses was estimated the highest at 90%. The main root causes are linked to poor agricultural practices that include poor management of pest and diseases, lack of irrigation systems, poor quality of farm input particularly seedlings. Other factors include market inaccessibility where farmers fail to get market of their produce thus opt to leaving their produce unharvested. Additionally, most farmers hardly receive extension services and incentive which contribute to more losses. Post-harvest losses are associated with insufficient storage facilities, bulk loading, poor handling during packaging, transportation, and offloading.

Various critical loss points where high estimates of FLW were recorded were identified in the value chain which are pre-harvesting estimated at 90% of the overall FLW which represented the production, harvesting levels, storage at the production level. At the post-harvest losses critical loss point was at the processing and packaging which maybe contributed to poor transportation to the collection centre and to the processing companies in Nairobi. Through this identified leverage points in the value chain map include the production, collection, and processing levels. Other points were on enabling environments which include business services, sciences and technology, quality standard and regulation, government, commercial laws, and enforcement.

Although Nandi avocado chain is at its initial development stage there are a lot of FLW being experienced which negatively affect the economy as well as GHG emission.

- The current economic value of FLW is estimated at KES. 33 million which would have been from avocado losses.
- These losses contribute to increase GHG emission with current estimate of carbo footprint at 652,483 $CO_2$-e/kg. This is attributed to poor waste management among the value chain actors where most of waste end up in landfills.

The analysis of FLW in this study conclusively provides a baseline for FLW reduction strategies in avocado chain in Nandi.

## 6.2 Recommendations

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

### 6.2.1 Shallow leverage points

**1. Enhance Sustainable Agricultural Practices**

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

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

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

### 6.2.2 Intermediate leverage points interventions

**3. Introduction of Agro-processing facility**

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

### 6.2.3 Deep Leverage points interventions

**4. Strengthen chain coordination through Collaboration**

This intervention aims at improving the robustness and stakeholders' capacity in the value chain. The main outcome is strengthening collaboration and collective action to improve and increase market access. Smallholder farmers in Nandi are constrained with various factors that prevent them from

competing favourably in avocado sector. Although the cooperative has managed to bring on board a large percentage of smallholder farmers and collaborated with few stakeholders there is poor coordination between these stakeholders. Public Private Partnership within the chain and increased collaboration of Nandi Avocado Farmers' Cooperative Society throughout the sector will enable avocado value chain in Nandi be competitive and resilient in both domestic and export market.

### 6.2.1 Theory of change

The expected implementation of the above interventions is presented in the theory of change where various strategies can be applied to attain suggested interventions. To enhance sustainable agricultural practices various activities, must be put in place which include grouping of farmers based on the sub-counties in Nandi. Arranging provides a proper way of planning farm visits and trainings. Other activities include trainings of farmers on good agricultural practices, integrated pest management and record keeping. Lastly there is also the need to set up a tree nursery by the cooperative and expected outcome from all these activities include reduction of farm loss to 20% and increase in production to 50%.

The major strategy of reducing PHL and maintaining the quality of avocado is establishment of cold storage are at Nandi Avocado farmers' Cooperative where avocado can be stored for a day or two awaiting collection this is done through construction of one aggregation centre at NAFCS and collection points within each subcounty.

For an Agro-processing facility to be introduced, a low-cost processing facility needs to be constructed followed by purchase of the avocado oil processing machine for low quality avocado and grinding machine for animal feed. The expected ultimate outcome is to reduce not only FLW but also GHG emissions.

Lastly, strengthening coordination through collaboration will requires a multistakeholder meetings and engagement. The outcome of this is expected to bring on board new stakeholders from public and private sector which will play a major role in improving market access, credit facilities and incentives and improve coordination.

Table 11:Theory of Change

| Activity | Inputs | Outputs | Intermediate Outcome | Ultimate Outcome |
|---|---|---|---|---|
| Grouping farmers based on sub counties | Allowances (Funds) | Farmers are grouped based on counties | -Reduce on-farm losses to 20%<br>-Increase production to 50% from the current production , Access to quality seedlings<br>-Production of quality avocado | 1. Enhance sustainable agricultural practices |
| Train staff and lead farmers<br>Train over 1000 farmers on GAP | Funds, farm tools, training kits, employ extension officer | Over 1000 farmers are trained on GAP | | |
| Train farmers on intergarted pest management | Funds, pheromone traps, | Ovetr 1000 farmers are trained on IPM | | |
| Train Farmers on record keeping | Funds, expert allowance | Over 1000 farmers are trained on record keeping | | |
| Setting up tree nursery | Purchase land, higher experts, funds for establishment | Avocado seedling nursery is set up | | |
| | | | | |
| Contruct avocado collection center for NAFCS | Funds, external consultants | One collection center is constructed<br>6 collection points are contructed | Reduction of FLW to 10% | 2. Establishmsnt of low cost temperature controled aggregation point facility |
| Establish collection points in each sub-county | | | | |
| | | | | |
| Construction of low-cost processing house for NAFCS | Funds, Employ 3 staffs | One low-cost processing house is constructed | Reduction of waste to 0%, Reduction of GHG emission to 5% | 3. Introduction of agroprocessing facility |
| Purchase of low-cost oil processing machine | | Oil processing machine purchased | | |
| Purchase of grinding machine for animal feed | | Grinding machine is purchsed | | |
| | | | | |
| Identification of key potential stakeholders | Allowances for facilitators | Potemtial stakholders are identified | Collaboration of NAFCS with Private sector(Banking institution, processing companies,exporting companies ), public sectors, research institution (KEMPHIS, KEFRI) , and Civil Society | 4. Strengthen chain coordination through Collaboration |
| Hold a multi-stakeholder meeting | Invitation of potential stakeholder to the meetins | Multi-stakolder meeting is held | | |
| | | | Increased access to markets | |
| | | | Access to credit facilities | |
| | | | Strengthened coordination, with all stakeholder | |

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## Annexes

Annex 1: Questionnaire

1. What is your gender*
   - ☐ Male
   - ☐ Female
   - ☐ Prefer not to say
2. How old are you?*

3. What is your education level?*
   - ☐ Primary School
   - ☐ High School
   - ☐ Diploma
   - ☐ Bachelor's Degree
   - ☐ Postgraduate
   - ☐ Other:

4. How many acres of land do you own?
   - ☐ 1/2
   - ☐ 1
   - ☐ 2
   - ☐ 3
5. What is the total Number of avocado do you produce per year?

6. What quantity of avocado do you produce per kg?

7. What variety of avocado do you produce?
   - ☐ Hass
   - ☐ Jumbo
   - ☐ Fuerte
8. What is the total amount of avocado do you sell?

9. What is the total cost of production?

10. Where do you sell your avocado to?

If other please explain
   - ☐ Consumers
   - ☐ Cooperative

- ☐ Traders
- ☐ Processors
- ☐ Wholesalers
- ☐ Retailers
- ☐ Other:

11. Where do you empty your avocados after harvest?

12. How much do you sell your avocado produce per kg?

13. Where do you get your seedling?

- ☐ KALRO
- ☐ Cooperative
- ☐ Commercial tree nursery
- ☐ Own nursery
- ☐ Other:

14. Are you a member of cooperative?

- ☐ Yes
- ☐ No

15. How satisfied with your cooperative?

Give reason for your choice

- ☐ Strongly agree
- ☐ Somewhat agree
- ☐ Neutral
- ☐ Somewhat disagree
- ☐ Strongly agree

16. Do you experience avocado losses after harvesting?
if yes state the potential causes

- ☐ Yes
- ☐ No

17. What do you do with avocado that doesn't end up to the market?

18. How often do you receive extension services?

- ☐ Every week
- ☐ Every Month
- ☐ Once a year
- ☐ Twice a year

☐ Not at all

19. Who offers the extension services?

20. Do you receive agricultural incentives?
If yes, how often?

21. Who provide the incentives?

22. What area do you think needs further improvement in avocado sector in Nandi to reduce avocado losses and waste?

Annex 2: Interview checklist

What is your role in avocado value chain?
Where do you source your avocado(meant for traders/ cooperative/retailers/wholesalers/exporters)
What is the total quantity of avocado do you receive?
What is the total quantity do your sale?
What do you use to transport avocado?
What do you use to package?
What is the total quantity of losses do you experience?
What are the potential causes of this loss?

Annex 3:Definition of FLW per value chain level

| Stage | Definition |
|---|---|
| Production | Avocado not harvested, those left in field, those uprooted and left i |
| Collection and Storage | Avocad lost during storage transportation from farm to collection centers |
| Processing | Lost due transportation, poor storage and packaging |
| Distribution | Lost due to poor storage and packaging |
| Consumption | Food lost due to bad storage and uneaten at home |

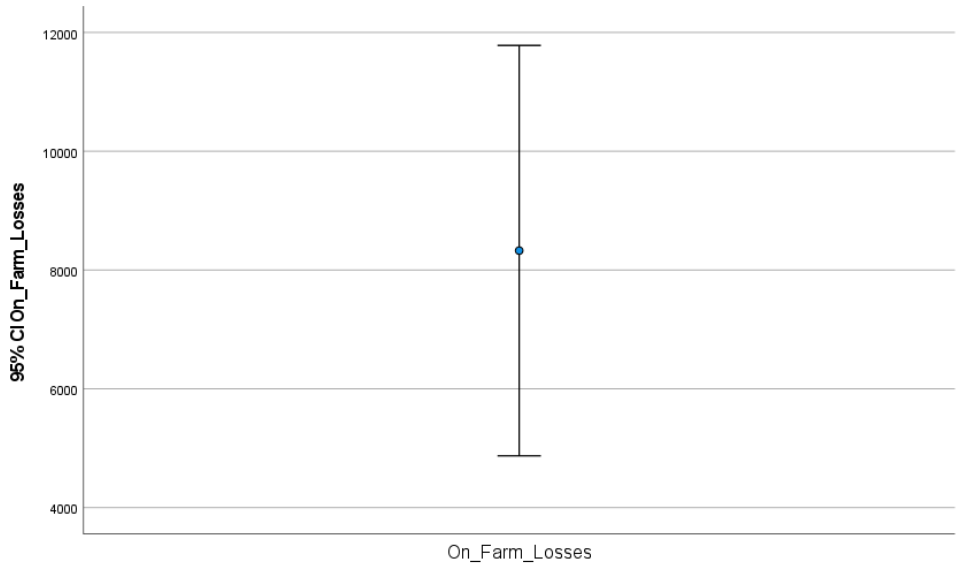
Annex 4: Statistical analysis of on-farm Losses

**One-Sample Statistics**

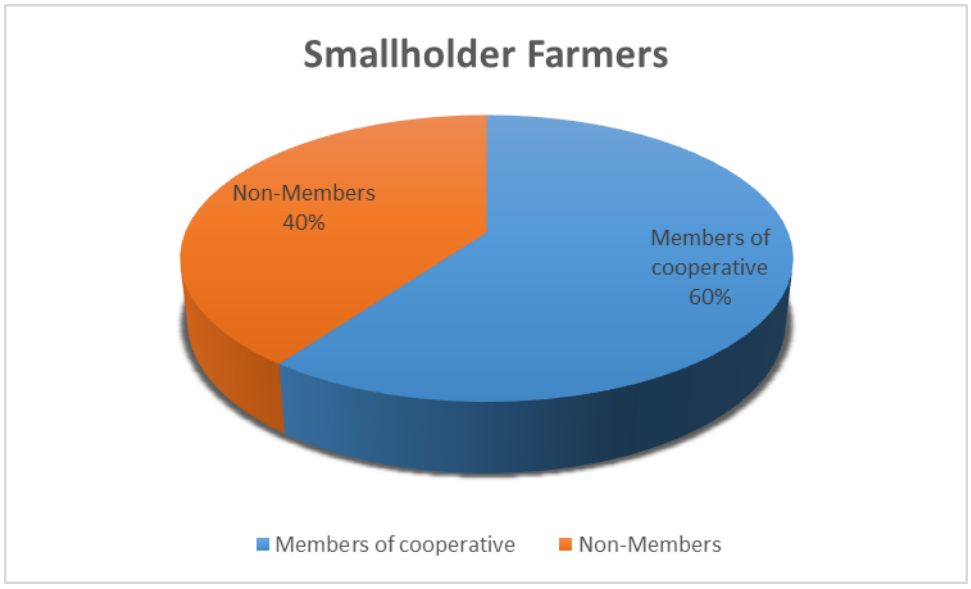
| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| On_Farm_Losses | 40 | 8327.78 | 10804.691 | 1708.372 |

**One-Sample Test**

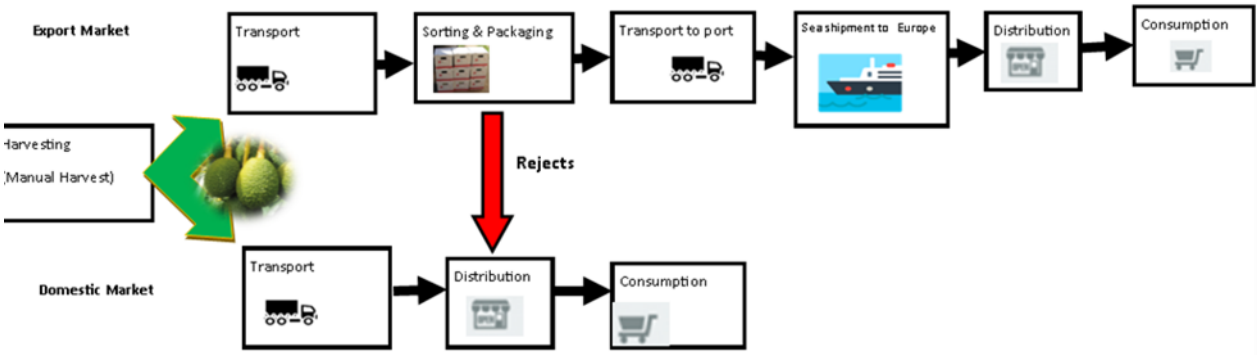
| | Test Value = 0 | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference Lower | Upper |
| On_Farm_Losses | 4.875 | 39 | <.001 | 8327.775 | 4872.27 | 11783.28 |



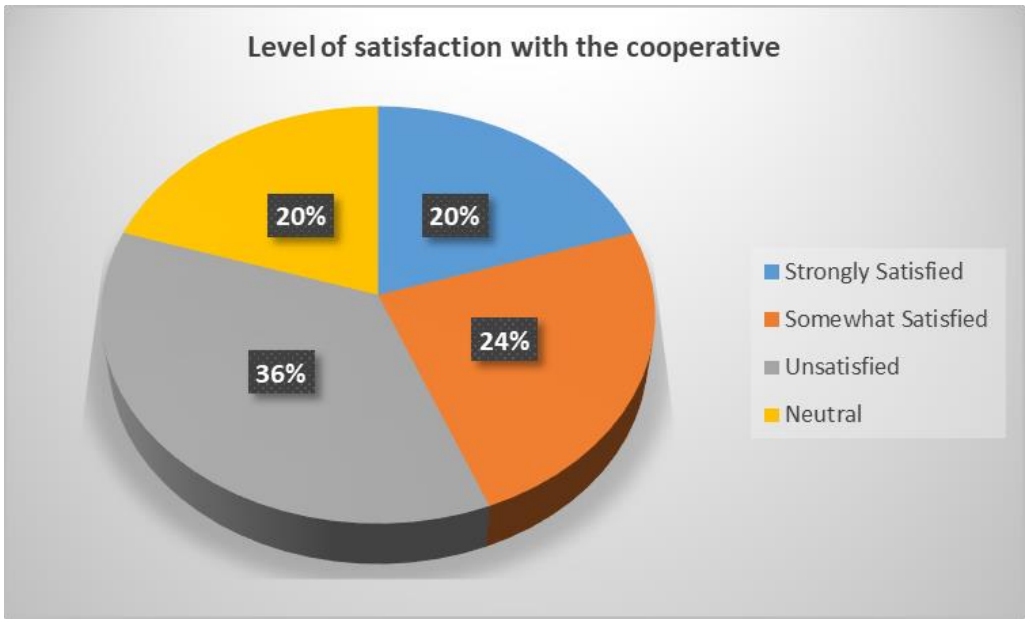

Annex 5: Division of smallholder Farmers in Nandi



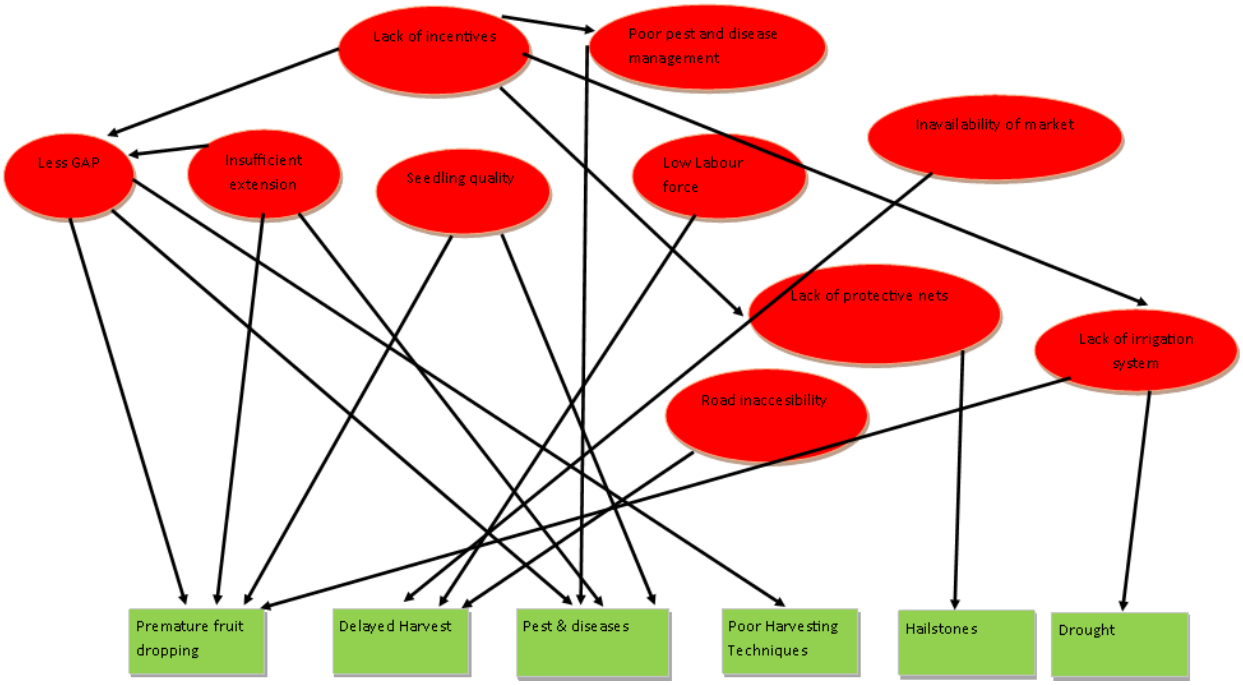
Annex 6: Avocado Supply Chain in Nandi County



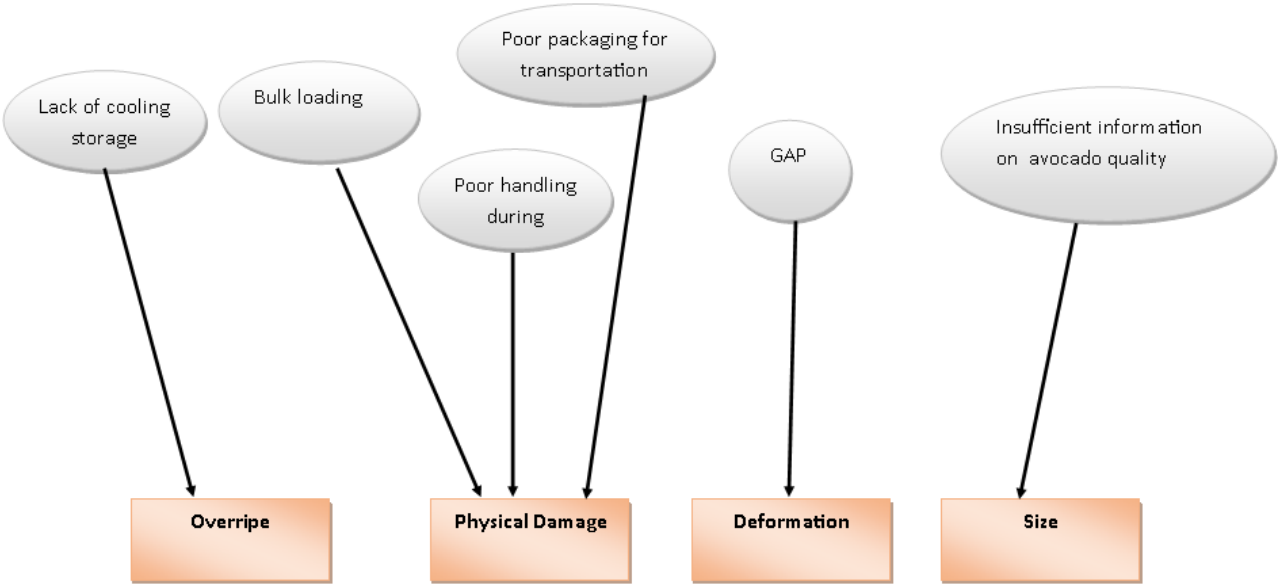

Annex 7: Level of satisfaction with the cooperative by the smallholder farmers



Annex 8: Root Causes tree of FLW at the Production Level




Annex 9: Root Cause Tree of FLW at the PHL



Annex 10:Causes of Rejects at the Collection Point

**Rejection_Causes**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Overipe, Physical Damage, Deformation, Size | 5 | 12.2 | 12.5 | 12.5 |
| | Overipe, Physical damage, Size | 2 | 4.9 | 5.0 | 17.5 |
| | Overipe | 5 | 12.2 | 12.5 | 30.0 |
| | Overipe,Physical Damage,Size,Disease | 3 | 7.3 | 7.5 | 37.5 |
| | Physical Damage, Size | 6 | 14.6 | 15.0 | 52.5 |
| | Overipe, Physical Damage | 14 | 34.1 | 35.0 | 87.5 |
| | Overipe, Physical Damage, Diseases, Deformation | 3 | 7.3 | 7.5 | 95.0 |
| | Physical Damage | 2 | 4.9 | 5.0 | 100.0 |
| | Total | 40 | 97.6 | 100.0 | |
| Missing | System | 1 | 2.4 | | |
| Total | | 41 | 100.0 | | |

Annex 11: Frequency Table for on-farm causes of FLW

**Case Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| $FLW_Causes[a] | 40 | 97.6% | 1 | 2.4% | 41 | 100.0% |

a. Dichotomy group tabulated at value 1.

**$FLW_Causes Frequencies**

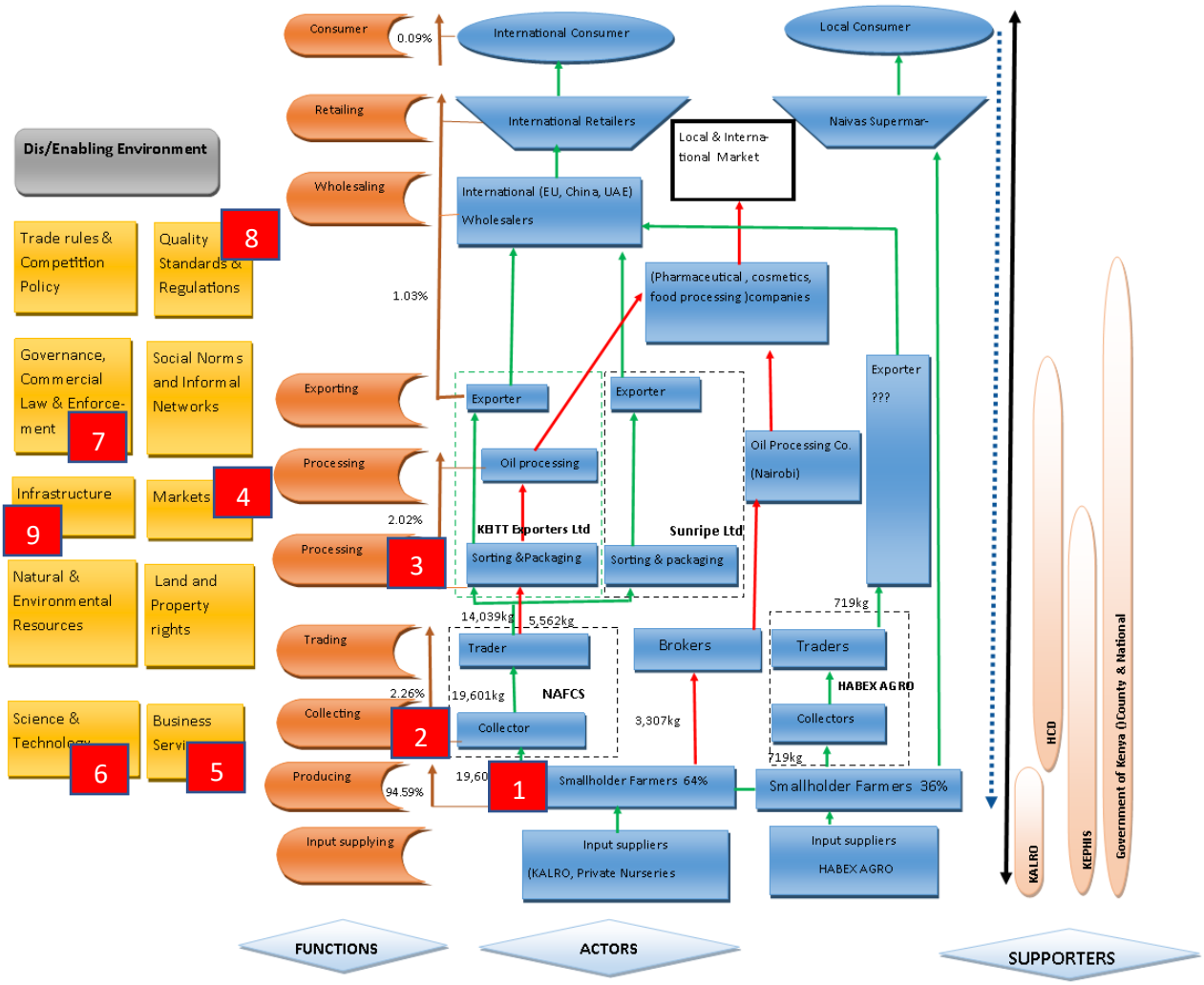
| | | Responses | | Percent of Cases |
|---|---|---|---|---|
| | | N | Percent | |
| OnFarm Causes[a] | Environmental_Cause | 33 | 47.8% | 82.5% |
| | Delayed_Harvesting | 18 | 26.1% | 45.0% |
| | Market_Condition | 8 | 11.6% | 20.0% |
| | Harvesting_Techniques | 5 | 7.2% | 12.5% |
| | Social_Factors | 5 | 7.2% | 12.5% |
| Total | | 69 | 100.0% | 172.5% |

a. Dichotomy group tabulated at value 1.

## Annex 12: Output Flow

| Stakeholders | Name stakeholder | Activities | Food Supply Chain Stages | Destination | Actual Losses | | Remark |
|---|---|---|---|---|---|---|---|
| | | | | | Weight(kg/yr) | weight % | |
| Producers | Farmers | Production<br>Harvesting | Production | Left on the field<br>Landfiled<br>Animal field | 309,957 | 90 | Avocado quality is good but they don't end up in FSC |
| Cooperative | NAFCS | Sorting<br>Collection<br>Trading | Collection and Storage | Left on the field<br>Animal field<br>Landfiled | 8,341 | 2 | Cooling Storage, transport and packaging issues |
| Trader | HABEX AGRO, 2 Local traders | Collection<br>Sorting<br>Trading | Collection and Storage | Left on the field<br>Animal field<br>Landfiled | | | |
| Brokers | Brokers | Collection<br>Trade | Collection and Storage | Uknown | | | |
| Processor | KEITT Exporters Limited | Sorting and Packaging | Processing | Oil Processing | 15365 | 5 | Storage and packaging issues |
| Prosessor | Sunripe Exporters Limited | Sorting and Packaging | Procesing | Disposed in pits | | | |
| Exporter | KEITT Exporters Limited | Logistics<br>Exporting | Distribution | Uknown | 7,836 | 2 | Cooling storage and transport issues |
| Exporter | Sunripe Exporters | Logistics<br>Exporting | | | | | |
| Retailer(Local) | NAIVAS, 2 Local Groceries | Retailing | Distribution | Landfield | | | |
| Retailer (International) | | Retailing | | Uknown | | | |

Annex 13: Leverage point in Nandi Avocado value chain




Annex 14: Frequency table of selling channels

**Buyers**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Cooperative | 19 | 47.5 | 47.5 | 47.5 |
| | Traders | 3 | 7.5 | 7.5 | 55.0 |
| | Brokers | 2 | 5.0 | 5.0 | 60.0 |
| | cooperative, Retailers | 1 | 2.5 | 2.5 | 62.5 |
| | Brokers, Traders | 8 | 20.0 | 20.0 | 82.5 |
| | Cooperative, Brokers | 7 | 17.5 | 17.5 | 100.0 |
| | Total | 40 | 100.0 | 100.0 | |

## Annex 15: Raw Data

| Respondents | Gender | Age | Education Level | No. of trees own | Hass G1 (Kg) | Hass G2 (Kg) | Fuerte G1 (Kg) | Fuerte G2 (Kg) | Area for emptying after harvest | Total Havest | Expected Harvest | Farm Losses | Occurance of rejetion | Causes of rejection | Animal Feeds | Home Consumption |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Samuel Kiplagat Bet | Male | 67 | High School | 12 | 400 | 610 | 0 | 0 | Sacks | 1010 | 2760 | 1750 | Yes | Overripe, Physical damage, Deformation, size | Yes | Yes |
| Simeon Matui | Male | 68 | High School | 15 | 120 | 1500 | 0 | 0 | Sacks | 1620 | 3450 | 1830 | Yes | Overripe, Physical damage, size | Yes | Yes |
| Mrs Caroline Tum | Female | 41 | Bachelors Degree | 45 | 85 | 400 | 0 | 0 | Buckets | 485 | 10350 | 9865 | Yes | Overripe | Yes | No |
| Benson Sawe | Male | 57 | Diploma | 15 | 250 | 760 | 0 | 0 | Ground | 1010 | 3450 | 2440 | Yes | Overripe, Physical damage, size | No | Yes |
| Eliud Togom | Male | 65 | High School | 15 | 0 | 600 | 0 | 0 | Buckets | 600 | 3450 | 2850 | Yes | Overripe, Physical damage, Deformation, size disease | Yes | Yes |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Desmond Brian Kiptoo | Male | 28 | Diploma | 5 | | 620 | 0 | 0 | Sacks | 620 | 1150 | 530 | Yes | Overripe, Physical damage | No | Yes | Yes |
| Mrs Betty Chemulai Nge | Female | 74 | High School | 18 | 0 | 0 | 0 | 2000 | Crates | 2000 | 4140 | 2140 | Yes | Overripe, other | Yes | Yes | Yes |
| Cleophas Letting | Male | 72 | Primary School | 29 | 0 | 0 | 0 | 1500 | Sacks | 1500 | 6670 | 5170 | Yes | Overripe | No | Yes | No |
| Rhisper Lagat | Female | 63 | Primary School | 20 | 0 | 0 | 130 | 320 | Ground | 450 | 4600 | 4150 | Yes | Physical damage size | No | Yes | No |
| Rosebella Birich | Female | 66 | High School | 6 | 170 | 0 | 0 | 0 | Buckets | 170 | 1380 | 1210 | Yes | Overripe, Physical damage | Yes | Yes | Yes |
| Salome Keino | Female | 60 | Primary School | 17 | 0 | 350 | 0 | 0 | Buckets | 350 | 3910 | 3560 | Yes | Physical damage | No | Yes | Yes |
| Nicholas K. Sirwa | Male | 70 | High School | 10 | 0 | 22 | 0 | 0 | Buckets | 22 | 2300 | 2278 | Yes | Overripe | No | No | No |
| Nelson K. Chepkwany | Male | 53 | Primary School | 80 | 0 | 220 | 0 | 0 | Sacks | 220 | 18400 | 18180 | Yes | Overripe, Physical damage | Yes | No | Yes |
| Amos Kimutai Chirchir | Male | 43 | High School | 31 | 200 | 100 | 0 | 30 | Sacks | 330 | 7130 | 6800 | Yes | Overripe, Physical damage, Deformation, size, other | No | Yes | Yes |
| Wilson Kiptoo Chirchir | Male | 48 | High School | 30 | 38 | 12 | 0 | 0 | Buckets | 50 | 6900 | 6850 | Yes | Overripe, Physical damage | Yes | Yes | Yes |
| Joseph Chirchir | Male | 47 | High School | 30 | 77 | 240 | 0 | 0 | Sacks | 317 | 6900 | 6583 | Yes | Overripe, Physical damage, Disease Deformation, | No | Yes | Yes |
| David Togom | Male | 59 | Primary School | 12 | 0 | 100 | 0 | 0 | Buckets | 100 | 2760 | 2660 | Yes | Overripe, Physical damage | No | Yes | Yes |
| Esbai Sigot | Male | 60 | Diploma | 400 | 12,137 | 14037 | 0 | 0 | Crates | 26174 | 92000 | 65826 | Yes | Physical damage, size | Yes | Yes | No |
| Solomon Saina | Male | 34 | High School | 35 | 400 | 0 | 0 | 0 | Sacks | 400 | 8050 | 7650 | Yes | Physical damage, size | Np | Yes | Yes |
| Eliud Mungen | Male | 45 | Primary School | 15 | 511 | 0 | 0 | 0 | Buckets | 511 | 3450 | 2939 | Yes | Physical damage, size | No | Yes | Yes |
| Joseph Bitok | Male | 38 | Diploma | 17 | 433 | 0 | 180 | 0 | Sacks | 613 | 3910 | 3297 | Yes | Overripe, Physical damage | Yes | Yes | Yes |
| Isaac Bitok Kibor | Male | 43 | Primary School | 45 | 22 | 235 | 0 | 0 | Sacks | 257 | 10350 | 10093 | Yes | Physical damage, Deformation | Yes | Yes | Yes |
| John Choge | Male | 50 | High School | 50 | 163 | 523 | 0 | 0 | Sacks | 686 | 11500 | 10814 | Yes | Overripe, Physical damage, Diseases Deformation | No | Yes | Yes |
| Dennis Mutai | Male | 29 | Diploma | 40 | 176 | 340 | 0 | 0 | Ground | 516 | 9200 | 8684 | Yes | Overripe, Physical damage | No | Yes | Yes |
| Salina Tuwei | Female | 38 | High School | 25 | 71 | 111 | 0 | 0 | Crates | 182 | 5750 | 5568 | Yes | Overripe, Physical damage, Deformation, | No | Yes | Yes |
| Samuel Serem | Male | 50 | Diploma | 127 | 0 | 162 | 0 | 38 | Buckets | 200 | 29210 | 29010 | Yes | Physical damage, size | No | Yes | Yes |
| Nancy Korir | Female | 48 | High School | 40 | 37 | 4 | 0 | 0 | Buckets | 41 | 9200 | 9159 | Yes | Physical damage, Deformation, size | Yes | Yes | Yes |
| Julius Kimaiyo | Male | 32 | High School | 40 | 26 | 0 | 0 | 0 | Buckets | 26 | 9200 | 9174 | | Overripe, Physical damage, size | No | Yes | Yes |
| Paul Cheset | Male | 49 | High School | 25 | 92 | 1250 | 0 | 0 | Sacks | 1342 | 5750 | 4408 | Yes | Overripe, Physical damage, Deformation, size | No | Yes | Yes |
| Elphas Ruto | Male | 41 | High School | 40 | 21 | 170 | 0 | 0 | Sacks | 191 | 9200 | 9009 | Yes | Physical damage, size | No | Yes | Yes |
| Peter Kiarrie | Male | 55 | Diploma | 40 | | 244 | 0 | 0 | Buckets | 244 | 9200 | 8956 | Yes | Overripe | No | No | Yes |
| Robert Birgen | Male | 62 | Primary School | 70 | 6 | 551 | 0 | 0 | Buckets | 557 | 16100 | 15543 | Yes | Physical damage | No | Yes | Yes |
| Thomas Chesire Rotich | Male | 38 | High School | 40 | 88 | 500 | 0 | 0 | Sacks | 588 | 9200 | 8612 | Yes | Overripe, Physical damage | No | Yes | Yes |
| Solomon Murithi | Male | 42 | High School | 10 | 34 | 130 | 0 | 0 | Ground | 164 | 2300 | 2136 | Yes | Physical damage Overipe | No | No | Yes |
| Andrean Birgen | Male | 29 | Diploma | 40 | 105 | 770 | 0 | 0 | Ground | 875 | 9200 | 8325 | No | Overripe, Physical damage | Yes | Yes | Yes |
| Joel Rotich | Male | 42 | High School | 20 | 187 | 645 | 0 | 0 | Sacks | 832 | 4600 | 3768 | Yes | Overripe, Physical damage, other | Yes | No | Yes |
| Pius Kimeli Saina | Male | 40 | Diploma | 35 | 227 | 87 | 0 | 0 | Sacks | 314 | 8050 | 7736 | Yes | Overripe, Physical damage, other | No | Yes | Yes |
| Wilson Maiyo | Male | 35 | High School | 11 | 25 | 117 | 0 | 0 | Buckets | 142 | 2530 | 2388 | Yes | Overripe, Physical damage, Deformation | No | Yes | Yes |
| Grace Maru | Female | 47 | Diploma | 70 | 560 | 120 | 0 | 0 | Sacks | 680 | 16100 | 15420 | Yes | Overripe, Physical damage, other | Yes | Yes | Yes |
| David Tanui | Male | 63 | Primary School | 26 | 26 | 204 | 0 | 0 | Ground | 230 | 5980 | 5750 | Yes | Physical damage, Deformation | Yes | Yes | Yes |

| ReJects management | Buyers | Price G1 Hass (ksh) | Price G1 Hass (ksh) | Price G2 Fuerte (ksh) | Cooperative Member | Satisfied | Reseason | Environmenta factors | Delayed Harvesting | Market Conditions | Harvesting Techniques | Theft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| home consumption, animal feeds | Cooperative | 67 | 20 | 0 | Yes | Neutral | N/A | Yes | Yes | No | No | No |
| Home consumption, disposed at the farm the overripe, animal feeds | Cooperative, | 67 | 20 | 0 | Yes | Somewhat satisfied | Delayed collection of avocado | Yes | Yes | No | Yes | No |
| domestic consumption, animal feeds | Cooperative | 67 | 20 | 0 | No | | N/A | No | No | Yes | No | No |
| throw at the farm, domestic consumption | Cooperative | 80 | 20 | 0 | Yes | Somewhat satisfied | Services provided are limited | Yes | No | No | No | No |
| domestic consumption, fed animals, disposed in the farm | Cooperative | 0 | 20 | 0 | Yes | Unsatisfied | services not upto expectation | Yes | No | No | No | No |
| home consumption, disposed in farms | Cooperative | 0 | 20 | 0 | No | | | Yes | No | No | No | |
| Feed cows, home consumption, disposed to the farm | Brokers | 0 | 0 | 35 | Yes | Unsatisfied | Delayed collection of avocado | Yes | No | No | Yes | No |
| Home consumption | Cooperative | | | 20 | No | | | Yes | No | Yes | No | No |
| domestic consumption | Cooperative | | | 20 | No | | | Yes | No | Yes | No | No |
| dispose at the farm, feed cattle, domestic consumption | Cooperative | 80 | 20 | 0 | Yes | Somewhat satisfied | Training on avocado production is needed | Yes | No | No | No | No |
| Home consumption, disposed at the farm | Cooperative | 0 | 20 | 0 | No | | | Yes | No | Yes | Yes | No |
| disposed at the farmer | Cooperative | 0 | 20 | 0 | Yes | Unsatisfied | No benefits | Yes | No | No | No | No |
| dispose overripe at the farm, feed animals | Cooperative | 0 | 20 | 0 | Yes | Somewhat satisfied | N/A | Yes | Yes | Yes | No | Yes |
| domestic consumption, farm manure | Cooperative | 80 | 20 | 20 | Yes | Somewhat satisfied | Delay of collection and payment | Yes | No | No | No | No |
| domestic consumption, Animal feeds, disposed in farms | Consumers | 80 | 20 | 0 | Yes | Strongly satisfied | Easy access to market | Yes | No | No | No | No |
| domestic consumption, disposed | Cooperative | 67 | 20 | 0 | No | | | No | No | No | Yes | No |
| Domestic consumption, Dispose | Cooperative | 0 | 20 | | No | | | Yes | No | No | No | No |
| feed animals, home consumption | Cooperative, Retailers | 80 | 30 | 0 | Yes | Unsatisfied | Poor coordination within the cooperative | Yes | No | No | No | No |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| local consumption, dispose at the farm | Traders | 70 | 0 | 0 | Yes | Unsatisfied | Late collection of avocado | Yes | No | Yes | No | No |
| domestic consumption, disposed off | Treaders | 70 | 0 | 0 | No | | | Yes | No | No | No | Yes |
| Sold direct to consumers, domestic use, dispose excess on farms | Traders | 70 | 0 | 0 | yes | Neutral | | Yes | Yes | Yes | No | No |
| sell to local market, home consumption, animal feed, farm manure | Brokers , Traders | 70 | 35 | 0 | Yes | Unsatisfied | Delayed collection | Yes | Yes | No | Yes | No |
| farm manure, home consumption | Brokers, Traders | 70 | 45 | 0 | Yes | Unsatisfied | Delayed collection, no extra services eg extension, seedling provision | Yes | No | No | No | Yes |
| home consumption, dispose excess | Brokers , Traders | 70 | 45 | 0 | No | | | No | Yes | Yes | No | No |
| home consumption, dispose at the farm | Brokers Traders | 70 | 45 | 0 | No | | | No | Yes | No | No | No |
| home consumption, excess disposed to farm | Brokers | 0 | 35 | 35 | Yes | Unsatisfied | delayed collection | Yes | Yes | No | No | Yes |
| feed animals, excess spoilt are disposed at the farm | Cooperative Brokers | 67 | 35 | 0 | Yes | Neutral | | Yes | No | No | No | No |
| home consumption, dispose | Cooperative | 80 | 0 | 0 | Yes | Neutral | | No | Yes | No | No | No |
| home consumption, dispose | Cooperative, Brokers , | 67 | 45 | 0 | No | | | No | Yes | No | No | No |
| home consumption, dispose at the farm | Brokers , Traders | 70 | 35 | 0 | Yes | Unsatisfied | No benefit | Yes | Yes | No | No | No |
| dispose at the farm | Cooperative, Brokers | 80 | 45 | 0 | Yes | Strongly satisfied | Good price, help to market | Yes | No | No | No | No |
| direct to consumers, retails, home consumption | Brokers , Traders | 70 | 45 | 0 | No | | | No | Yes | No | No | No |
| give out, home consumption | Cooperative, Brokers | 67 | 45 | 0 | Yes | Strongly satisfied | Fair price of avocado | Yes | Yes | No | No | No |
| Dispose to farm | Coperative | 70 | 20 | 0 | No | | | Yes | No | No | No | No |
| animal feeds,home consumption, excess are disposed to the farm | Brokers, Traders | 70 | 35 | 0 | No | | | Yes | Yes | No | No | Yes |
| animal feeds, dispose at the farm as manure | Cooperative | 80 | 20 | 0 | Yes | Neutral | | Yes | Yes | No | No | No |
| dispose, home consumption | Cooperative Brokers | 80 | 45 | 0 | Yes | Strongly satisfied | Fair price | Yes | Yes | No | No | No |
| home consumption, dispose at the farm | Brokers Traders | 70 | 40 | 0 | No | | | Yes | Yes | No | No | No |
| home consumption, animal feeds | Cooperative, Brokers | 67 | 45 | 0 | Yes | Somewhat satisfied | no complete help regarding seedlings acquisition, | Yes | Yes | No | No | No |
| home consumption, animal feeds, dispose at the farm | Cooperative, Brokers , | 67 | 20 | 0 | Yes | Strongly satisfied | they buy rejects of grade 1 | Yes | No | No | No | No |

| f loss | Extension suervices | Improvement areases |
|---|---|---|
| Premature dropping , Delayed Harvest | Not at all | Extension service, Harvesting time should be tracked to avoid overripe |
| Delayed collection, Pest and diseases, Improper harvesting | Not at all | Issues with market, Extension services, Trainings on avocado management, increase number of export and processing company |
| ıarket | Not at all | Market accessibility |
| disease, hail stones, premature falling of fruits | Not at all | Information flow regarding prices (no proper statement), training service |
| e, Drought | Not at all | Sensitization of farmers, seedlings issues, Provision of nets for hail stone |
| Hail stones, drought, premature dropping | Not at all | Harvest training, Seedling sourcing, incentives , training on avocado prod |
| Some trees have overgrown hence difficult to reach fruits, hailstones, pest and | Not at all | Women need to be sensitized, training on production, seedlings issues, L |
| No ready reliable market, poor management, Pest and diseases | Not at all | Extension services, Training of farmers, Sensitization on importance of co |
| Lack of market, fruit abortion | Not at all | Quality Seedlings needed, Sensitization on joining cooperative, best ways to deal with pest and diseases, Training on production |
| Diseases and pest, hailstones | Not at all | Training on production |
| Lack of ready market, pest and diseases, difficulty in harvesting | Not at all | Extension services, market accessibility, quality seedlings |
| Hailstones, premature dropping of fruits, diseases, drought | Not at all | Pest and disease management need to be dealt with |
| Drought, theft, hailstones, lack of market, late collection by the cooperative | Not at all | Training on production of avocado, quality seedlings, exposure of farmers to thriving farma ega Kakuzi, Information related to prices, |
| Hailstones, Pest and diseases | Not at all | seedling supply, Market on time |
| e, Drought | Not at all | Trainings on avocado establishment and management, pest and diseases |
| vesting methods | Not at all | Training on production and harvesting, incentive to support farmers, info |
| , Hailstones | Not at all | Markets, Extension services, Training |
| Hailstones , Drought, diseases | Not at all | seedlings quality, hail damages, price negotiation, record keeping soil tes |

| | | | |
|---|---|---|---|
| Lack of market, Drought, hailstones | Not at all | Market access | |
| Hailstones, theft, pest and diseases | Not at all | Market access, nets to prevent hailstones, irrigation system | |
| Delayed harvest, drought, deases and pest, lack of direct market | Not at all | cooperative to work on training farmers and providing extension services | |
| Delayed collection, difficult harvesting tall trees, fruit abortion | Not at all | Market | |
| Hailstones, theft, diseases and pest | Not at all | Extension services, cooperative to be proactive, benchmarking to farmers | |
| Delayed collection, lack market | Once a year | | |
| collection, | Not at all | Market, extension services | |
| delayed harvest, pest and diseases, theft | Not at all | Cooperative should have proper coordination | |
| Hailstones, Drought, fruit disease | Yes | Market access, pest and disease management | |
| harvest | yes | Cooperative to support farmers in getting market, need for training | |
| harvest | yes | Access to market, quality input | |
| harvest, drought | yes | Market access, quality seedlings | |
| Delayed harvest, hailstones, drought | Not at all | More market, Price negotiation should also involve farmers, quality seed | |
| Delayed Harvest, most avocado rot while at the farm | yes | Timely collection, market, sensitization on importance of cooperative | |
| fruit abortion, delayed harvest, hailstones | yes | Market access, quality seedlings, trainings | |
| es, Diseases | Not at all | | |
| hailstones, drought, delayed harvest, theft | yes | Market Access, sensitization of cooperative, quality farm input | |
| delayed harvest | yes | access to more market, quality supply of input, trainings | |
| Pest and diseases, delayed harvest | yes | Market access, disease management ways, trainings, extension services | |
| drought, delayed harvest, hailstones | yes | hailstones management, irrigation systems to be provided, alternative m | |
| delayed harvest and collection, hailstones, Drought, disease management | yes | the cooperative to help farmers in trainings, quality seedlings, pest and d | |
| es, diseases | Not at all | Provision of quality seedlings, market access, timely collection of avocad | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **G1 Hass** | **G2 Hass** | **G1 Fuerte** | **G2 Fuerte** | | **Buckets** | 14 | 1400 | 35 | |
| | | **Cooperative sales** | 16,687 | 25734 | 310 | 3888 | 46,619 | Crates | 3 | 300 | 8 | |
| | | **Brokers** | | 5184 | | 2000 | 7,184 | Sacks | 17 | 1,700 | 43 | |
| | | **Retail** | | 14037 | | | 14,037 | Ground | 6 | 600 | 15 | |
| | | **Traders Habex S** | 1933 | | | | 1,933 | | 40 | | | |
| | | **Total Current Pr** | 69,773 | | G1 | 16,997 | | | | | | |
| | | | | | G2 | 29622 | | | | | | What is produced |
| | | **Expected total Production** | **No of trees** | **standandard production per tree** | **379730** | | | | | | | What is sold |
| | | | 1,651 | 230 | | | | | | | | |
| | | | | | | | | | | | | |
| | | | **Losses waste at the production level** | | | | | | | | | |
| Expected Total Production | | | **379730** | | | | | | | | | |
| Total Current Produce | | | **69,773** | | | | | | | | | |
| | Loss | | **309,957** | (Total expected production -Total Current Proction ) | | | | | | | | |
| | | | | | | | | | | | | |
| | | | **Losses at the collection and storage** | | | | | | | | | |
| Total collected | | | **69,773** | Total current produce | 6279.57 | | | | | | | |
| | Rejects | | **8,341** | | | | | | | | | |
| | Collected after sorting | | **61,459** | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | **Losses at Processing and packaging** | | | | | | | | | |
| | Total Collected | | **61,459** | (Total collection at the collection center and storage-Losses at the collection center) | | | | | | | | |
| | Loss | | **15,365** | 25% of the total collected | | | | | | | | |
| | | | **Waste at the distribution** | | | | | | | | | |
| | Total collected | | **46,094** | (Total collection at the processing and packaging-Losses at the processing and packaging) | | | | | | | | |
| | Waste | | **7,836** | 17% of the total collected | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | **Losses at consumption** | | | | | | | | | |
| | Total collection | | **38,258** | (Total collection at the distribution -waste at the distribution) | | | | | | | | |
| | waste | | **1,913** | 5% of the total collection | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

| **Stakeholder** | **Estimated Buying price (ksh/kg)** |
|---|---|
| Farmer | |
| Broker | 45 |
| trader | 70 |
| Cooperative | 74 |
| wholesale price | 30 |
| Exporter | 80 |
| retail price (Local) | 35 |

Annex 16: Interviews transcripts

**Types of experts**

Government and Local Ministries

National Research Institutes

Farmer organization/Cooperatives

Farmers

Broker/Traders

Transporting companies

Processors

Wholesalers

Retailers

**Type of this experts**

1. Supply chain links
2. External actors (Based on knowledge, technical background)

**Cooperative data**

**Serem Chairman**

We cover 6 subcounty. We have over 1000 member who practice 42 avocado farmer. We work with ministry of agriculture and cooperative and we bring farmers together and our main goal is we do marketing from them.

Main problem include prices and market. We currently don't have packhouse hence we depend mostly of the transporters from the processing and export company. Most of the time they arrive late hence most avocado end up getting spoiled.

Other problems include pests and diseases (FCM), sunburns, animal like monkeys attacks on trees and feed on overripe avocado. Rejected avocado are sold locally but not all since in Nandi almost every household has avocado tree hence it is difficult to get market at the domestic level. We still have less exporters in Nandi. This year the cooperative has collaborated with an exporter who buys both good avocado and the rejected one at a fair price to reduce wastage which goes to the oil processing company.

Fluctuation of prices is another problems. Cooperative is collaborating with the county government to set up the Parkhouse, Introduction on aggregation centre with cold-rooms to store avocado before they reach the export market. Assist farmers to keep their produce before they get market. The cooperative is doing sensitization , field days have been done twice.

When it comes to prices, prices are determined by world market. Farmers prices are still low compared to what is being sold at the retailing level in export market.

Quality is also a problem and farmers are encouraged to work with the extensions officers. There in need for an extension officer, as a cooperative we need more extension services to reach the farmers to get agronomic advisers. Quality also depend on seedlings. There are nurseries which we are looking in to get best seedlings for our farmers. The county government are trying to introduce more nurseries to work with the cooperative to get best seedlings.

**Increase in Farmers**

Some delegates have been chosen to sensitize farmers on joining the cooperative. Negotiate good prices, Field days for every subcounty to increase member, HCD also assisting to have some field day to encourage farmers to join. Process

**Paul Tirop, Production and marketing officer**

We try to look for market after checking the maturity of the avocado from farmers. Before the cooperative farmers have been suffering in the hand of middlemen who exploit farmers hence framers are not seeing the benefit of avocado farming. Current most framers are appreciating the importance of cooperative because the fruits are now sold in best prices and reliable bargaining power is done by the cooperative. As a cooperative we ensure all the fruits are collected both grade one and two. We try to reduce the amount of grade two however we still face natural challenges such as hailstones and infestation we loose most of the crop which increases loses. FCM is the common pest in Nandi.

We try to liaise with the exporters in order to help farmers get training on ways to produce quality fruits which is expected in the export market. There also the issues of information most farmers are not well informed regarding farming practices eg good agricultural practices. We currently focus on the export market not local market because the local market has local variety. Also the local market does not fetch favourable prices to farmers. Another issue is that most avocado furte and Hass have certain size which is small yet the local varies are much bigger hence consumers will always choose the bigger one.

Harvesting is another problem. Most farmers use the conventional way of harvesting sometimes using sticks which injures the fruits.

In future we plan to work with certification bodies. We look forward to concentrate on organic farming.

**Nancy (Agricultural officer Nandi County)**

A an agricultural officer together with others we usually advice farmers on tree management such as pruning, we direct them on the type of inputs to get and what time to get. For avocado we advise them to get affordable and quality seedlings. We advise on how to manage pest and diseases which include recommending pheromone traps and type of chemicals to use. We help on advising them on pruning and weeding

Challenges the famers are issues related to pruning, interlocking of trees. Some farmers have a lot of weeds because they believe trees don't need pruning. This results to spread of diseases and pest. Most farmers don't have irrigation system hence the plants dry and fruits turns dry. The farming system is mostly mixed farming.

Farmers are experiencing wastages especially last year dues to hailstones. Last year most farmers had their first produce although we had only one exporter which only took grade one avocado while the rejects were returned to the farmers. However this year we have a new exporter who buys all the avocado regardless of the issues but the are sorted into grade one and two. The grade two are used for oil processing.

The current challenge I have noticed is that at the production part. A farmer get seedlings but cant trace where the seedlings where they only noticed after two to three years. Farmers need to liase with the agricultural officers in order to get the desired produce.

**Traders/Broker**

I buy avocado from farmers. I provide ready market to them with no delay of payment. Most of the avocado I sell to oil processing company in Thika, Nairobi. I don't experience rejects. I only buy avocadoes that have good appearance.

**Retailers**

Losses occur but not that much. Most of our customers prefer local variety of avocado which are big in size compared to hass and fuerte. We usually dispose our avocado in pit if they are spolt.

Our prices range from 30-45 shillings per kilo

**Processors KEITT**

No response.

**Exporter (Sunripe) Manager Wafula**

We can give you some information, but how it currently works is that all the fruit we get is either exported or sold for oil processing

So there is very little waste except for what is left at farm-gate and a lot of this ends up in local markets

Obviously from the losses you would look at potential opportunities and interventions, and ideally these would be value additions

**Procedures of sorting**

Chemical residues

Lenticells on fruit

Premature fruit

Deformation

Undersize

Mechanical damage

Pest damage

**Waste management**

All spoilt avocados are dumped in a whole.

Trainings are done about harvest, agronomy, pruning, quality management to farmers who are member cooperative.

Nandi is yet to be certified since it new although Sunripe tries to help farmers from other regions to get in other avocado producing regions.

**KALRO OFFICIAL**

KALRO has developed environmentally friendly integrated pest management options for the control of fruit fly on avocado over the years. Pheromone traps, field sanitation, attractant use, and soft chemicals are among them. If these technologies were widely distributed among farmers, they would reduce infestation by at least 20%. Farmers would also be trained on the appropriate maturity index, ensuring that only mature fruits are marketed. Subsequent activities include

- Obtain high-quality planting materials of KALRO-developed avocado varieties.
- Disseminate KALRO-developed avocado production technologies.
- IPM and good agronomic practices capacity building (GAP)
- Make inputs for IPM more readily available.
- Connect farmers with markets and input suppliers.
- Establish and operationalize value chain innovation platforms
- Increase value creation and job creation

**Habex Agro**

Habex Agro, an agricultural company based in Eldoret, Kenya with the specialty in avocado and macadamia farming has rolled out a program to ensure farmer in six counties in Rift Valley namely Uasin Gishu, Elgeyo Marakwet, Nandi, Kericho, Tranzoia, and Baringo take advantage of the lucrative avocado industry by contracting them to plant avocados. The company is issuing farmers with avocado seedlings on credit together with advice and extension services till the crops are ready for harvest and production.

Annex 17: Unharvested Avocados

Annex 18: Traditional Pest and disease Management

Annex 19: Unharvested Avocado at the farm

Annex 20: Harvested Avocado

Annex 21: Pest Management using pheromone traps

Annex 22: Mixed Farming

Annex 23: Bulk Package in Sacks