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Assessment of Post-harvest Losses across the Avocado Value-chain in Ethiopia

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ABBREVIATIONS AND ACRONYMS

ATI	Agricultural Transformation Institute
BoA	Bureau of Agriculture
CAC	Codex Alimentarius Commission
CCFFV	Codex Committee on Fresh Fruits and Vegetables
CLP	Critical Loss Point
CU	Control Union
EFDA	Ethiopian Food and Drugs Regulatory Administration
EHPEA	Ethiopian Horticulture Producers and Exporters Associations
EIAR	Ethiopian Institute of Agricultural Research
ESS	Ethiopian Statistical Services
EAS	Ethiopian Accreditation Services
ETFRUIT	Ethiopian Fruits & Vegetables Marketing S.C
EHNRI	Ethiopian Health and Nutrition Research Institute
FAO	Food and Agriculture Organization of the United Nations
FLW	Food Loss and Waste
FSC	Food Supply Chain
FSMS	Food Safety Management System
GAIN	Global Alliance for Improved Nutrition
GAP	Good Agricultural Practices
GHG	Greenhouse Gas
GHP	Good Hygienic Practices
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HACCP	Hazard Analysis and Critical Control Point
IES	Institute of Ethiopian Standards
HDPE	High-Density Polyethylene
ISO	International Organization for Standardization
MARC	Melkassa Agricultural Research Center
MRL	Maximum Residue Limit
MoA	Ministry of Agriculture
MoH	Ministry of Health

MoLS	Ministry of Labor and Skills
MoTI	Ministry of Trade and Industry
MoTL	Ministry of Transport and Logistics
MoTRI	Ministry of Trade and Regional Integration
NADP	National Avocado Development Program
NGO	Non-Governmental Organization
PH	Postharvest
PHL	Postharvest loss
QMS	Quality Management System
RAISE-FS	Resilient Agriculture for Inclusive and Sustainable Food Systems
SAA	Sasakawa Africa Association
SC	Supply Chain
SDG	Sustainable Development Goals
SHF	Small Holder Farmer
SNV	Netherlands Development Organization
SSA	Sub-Saharan Africa
TIMPs	Technology, Information, Management and Practices
UNECE	United Nations Economic Commission for Europe

TABLE OF CONTENTS

LISTS OF TABLES

LISTS OF FIGURES

EXECUTIVE SUMMARY

Avocado is the second most extensively cultivated fruit in Ethiopia, after bananas, holding 19% of the total area allocated to fruit growing and contributing to 17% of the overall fruit production, winning the third position in production volume. Avocado production has progressively increased since 2008/2009, particularly after 2019/2020, owing to the government's focus on this commodity and the involvement of smallholder farmers in commercial production. As a result, the country has begun exporting graded and packed avocados to international markets. Domestic demand is expanding due to urbanization and rising incomes while agro-processing plants are also increasingly focusing on value addition, notably crude oil processing.

However, the avocado sector faces several challenges, including significant postharvest losses (PHL), which impact food security, nutrition, and economic security. Besides, postharvest losses quantified as both quantitative (mass or volume) and qualitative (edibility, nutrition) losses, lead to reduced food availability, increased prices, and resource wastage, contributing to greenhouse gas (GHG) emissions. Limited data on postharvest losses, coupled with a lack of standardized assessment methodologies, complicates efforts to address these losses.

This study was undertaken to bridge the existing gaps by producing objective data on avocado losses across the harvest and postharvest supply chain. It also explored the pre- and post-harvest handling and management practices that contribute to these losses, as well as the associated economic, nutritional, and environmental impacts of avocado fruit losses. It also aimed to evaluate the "Customized Food Loss and Waste (FLW) Quantification Methodology" for accurately quantifying avocado losses and identifying significant loss points. Based on the identified gaps, the project intended to improve the awareness, knowledge, and skills of key stakeholders on better handling and management of avocado postharvest losses.

The study was conducted in six major avocado-growing regions of Ethiopia, including Oromia, Sidama, South Ethiopia, South West Ethiopia, Central Ethiopia, and Amhara. It employed a cross-sectional design and gathered both qualitative and quantitative data on demographics, socio-economics, pre-and post-harvest avocado management and handling practices, and estimated avocado fruit losses along the harvest and postharvest chain using both a survey and load-tracking method.

The results revealed that farmers' pre-harvest management and handling practices are sub-optimal, primarily due to inadequate extension services leading to poor skill sets, substandard agronomic practices, limited access to grafted varieties, insufficient water access, low input use, and issues with pests and diseases. Although the Ministry of Agriculture (MoA) and its line offices offer modest extension services to farmers growing commercial avocado varieties, there is a notable gap in extending these services to local avocado growers and the broader array of actors within the avocado supply chain. These deficiencies significantly contribute to substantial harvest and postharvest losses of avocados.

In the study areas, three main types of avocado production systems were identified: smallholder farmers' commercial production in clusters, local cultivar-based production, and a mixed system combining both commercial and local avocado varieties. Commercial avocado varieties such as Hass and Ettinger are widely grown in North Gojjam, East Shewa, and Silte, and less so in Jimma, Wolaita, and Sidama, with Hass being the most common. Conversely, most farmers in Jimma, Kaffa, Wolaita, and Sidama areas grow local avocado trees from seeds under rainfed conditions using traditional methods, and letting the trees grow and develop freely for several years without tending and use of irrigation or nutrients.

Avocado fruit loss is caused by several factors, including pre-harvest management, poor harvest maturity, inadequate harvesting practices, rough handling, mechanical injuries during loading, transporting, and unloading, as well as insufficient temperature management throughout the supply chain.

Avocado harvesting dates and frequency are influenced by various factors such as variety, climate, agroecology, and management practices, with some areas harvesting once, twice, or even several times a year. In most areas, commercial avocado varieties and larger fruit local varieties in southwestern Ethiopia have a single harvesting season, typically from July to September. Smaller fruit local varieties, mainly of Mexican origin, are harvested twice a year in Wolaita and Sidama, with the first season in February-March and the second in late July-August. In areas with continuous rainfall, such as Tullo and Cheta Woredas in the Kaffa Zone, avocados are harvested nearly year-round due to prolonged flowering and harvesting periods.

Avocado harvesting among growers typically involves traditional methods, where children climb trees and use long sticks to collect the fruit, often dropping it from higher heights. This leads to breakage, bruising, as well as contamination, and spoilage when the fruit contacts the ground. Additionally, the absence of precooling or washing further compromises the quality. On a positive note, growers do engage in sorting, grading, and packaging of the avocado fruits.

Despite the need for temperature and humidity control facilities for avocado fruits, supply chain actors do not use such facilities. Consequently, fresh avocados are transported like grain crops across the country, resulting in significant losses before they reach consumers.

Avocado farmers are less organized, which hinders their ability to negotiate prices and contracts with buyers, and they often fail to meet market quality and quantity standards, and the price declines seasonally. Consequently, wholesalers set the prices at both the farm gate and local markets, leaving producers with minimal influence over pricing and resulting in unfair pricing practices. Moreover, wholesalers dominate the market by capturing the largest share of the market margin at 32.0% and the highest profit margin at 39.6%. In stark contrast, producers receive a much smaller portion, with only 12.8% of the market margin and a meager 7.5% of the profit margin.

Regarding avocado harvest and postharvest losses, the survey method estimated total losses at 39%, with 23.46% attributed to quantity loss and 15.54% to quality loss. In contrast, the load tracking method indicated an average total loss of 43.2%, consisting of 24.5% quantity loss and 18.7% quality loss. The load tracking method estimated a total loss that was 4% higher than the survey method, although both methods showed similar quantitative loss results, with the load tracking method indicating a slight 1% increase. Overall, avocado losses during harvest and the supply chain range from 39% to 43%, averaging around 41%, suggesting that only about 60% of fresh avocado production reaches last-mile users. The critical loss points (CLP) with the greatest impact on food security and economic outcomes were found at the retail market (12.5%), during wholesaler storage and marketing (11.2%), and at the harvesting stage (8.9%).

The study also estimated the impacts of avocado fruit loss on the economy, nutrition, food security, land resource utilization, and the environment. Using the 2020/2021 production data and the current market price for a kilogram of avocados, the estimated total economic loss for that specific season amounts to 5 billion Birr. Annually, the loss of 58 million kg of avocados could have met the food energy needs of 61,431 adults, provided the protein requirements for 2.4 million adults, and fulfilled the carbohydrate needs of 5,316 adults. Moreover, the lost avocados could have supplied the yearly nutrient needs for 194,371 adults in folate, 133,009 adults in potassium, and 66,276 adults in magnesium. It is also estimated that 249 billion kilocalories of food energy were lost, which could have supported 99.7 million adults for a day or sustained 136,526 adults for a year. Regarding land resource wastage, inefficiencies in avocado production and marketing rendered 7,494 hectares of land unproductive annually. Additionally, the loss of 63,669.5 tons of avocados resulted in greenhouse gas (GHG) emissions equivalent to 159,249 tons of CO_2.

Avocado fruit exports in Ethiopia are a relatively new development, having only begun in the previous decade. As a result, the current state of exporters within the avocado supply chain is marked by a lack of organization and fragmentation, with a notable absence of centralized control and management. Furthermore, many exporters are not adequately informed about the specific requirements of international avocado markets, such as Global GAP and other critical export certifications. Comprehensive information remains elusive, and documentation practices are generally substandard. The Hass variety leads the avocado exports from Ethiopia. Exporters typically purchase Hass avocados from Primary Avocado Growers Cooperatives, avocado cluster growers, and individual farmers rather than owning their own farms. This setup poses significant challenges, particularly in securing quality fruits in sufficient quantities from smallholder farmers. Additionally, the fresh market price for Hass avocados often surpasses the prices offered by exporters, making it difficult to maintain a competitive edge in the export market.

Despite the presence of up to twelve factories dedicated to the production of crude avocado oil, and the majority of pressing facilities having large capacities (processing between 50 to 60 tons of ripened fruit daily), there is a shortage of high-quality fresh fruits. Most avocado trees in Sidama and southwestern Ethiopia are local types, likely yielding lower amounts of fresh fruit

and oil. Additionally, oil processors face significant competition from local traders who purchase Hass avocados for the local market at higher prices than what companies offer.

Overall, the study highlighted that the avocado value chain in Ethiopia is underdeveloped and requires multifaceted interventions to address the various challenges it faces. Key areas for intervention include improving the knowledge and skills of avocado growers and extension agents, developing capacity along the avocado value chain, investing in avocado infrastructure, research and extension, and technology development, promoting market linkages, empowering women in avocado value chains, establishing a robust quality control mechanism, and improving coordination and collaboration.

1. INTRODUCTION

1.1. Trends of Avocado Production and Productivity in Ethiopia

Avocado is the second most produced fruit in Ethiopia after banana in terms of area coverage (19%) and ranks third (17%) in national fruit production. Ethiopia is one of the top five avocado producers in sub-Saharan Africa with the main avocado season lasting from August to October.

In recent years, Ethiopia has prioritized avocado as an important commodity supported by different policy and strategy documents, including the Agriculture Sector Ten Years Perspective Plan and the 10-in-10 initiative. Agricultural Commercialization Clusters (ACCs) and CAADP-NAIP have also prioritized avocado development. Because of these multiple factors, the Ministry of Agriculture of Ethiopia launched a National Avocado Development (NAD) project. The crop has a high domestic and export market potential.

The area and production of avocados in Ethiopia have been steadily growing since 2008/2009 (Figure 1.1.1 & 1.1.2; CSA, 2004/2005-2017/2018), while the commercial Hass variety has received much attention. However, reports from several regional states (from both local and commercial avocado types) are significantly higher than those reported by the National Statistical Service, suggesting that the area and production of avocados may actually be larger.

Avocado production has particularly seen an exponential rise since 2019/ 2020 largely due to the Government's commitment. The rise of smallholder farmers engaging in avocado production in commercial clustered orchards has contributed to the expansion of commercial avocado production, with notable areas including East Shewa, North Gojjam, Silte, and several other new pocket areas in Ethiopia.

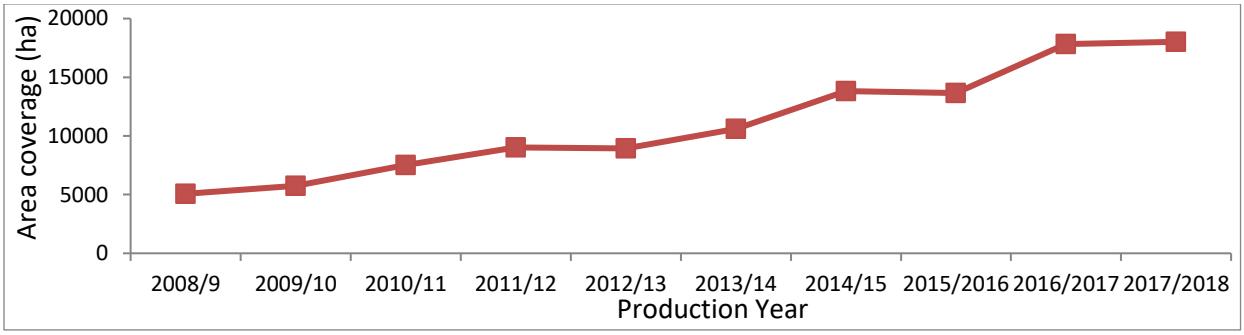

Figure 1.1.1: Area coverage of avocado fruits in Ethiopia (CSA, 2008/2009-2017/2018)

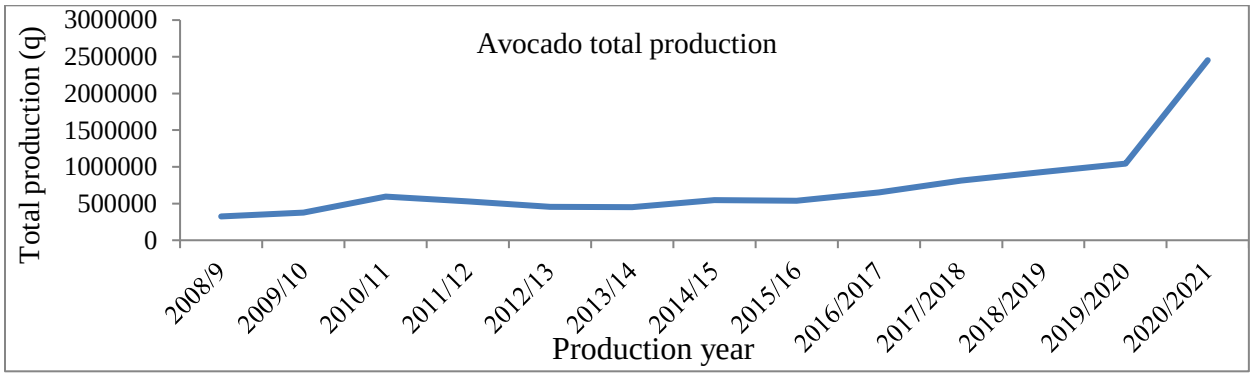

Figure 1.1.2: Ethiopian avocado production trends (CSA, 2008/2009-2020/2021)

With regard to avocado marketing in Ethiopia, the value chain for avocados encompasses multiple actors including producers, collectors/traders, processors, wholesalers and retailers in central markets in Addis Ababa and other cities and towns, and retailers in local markets.

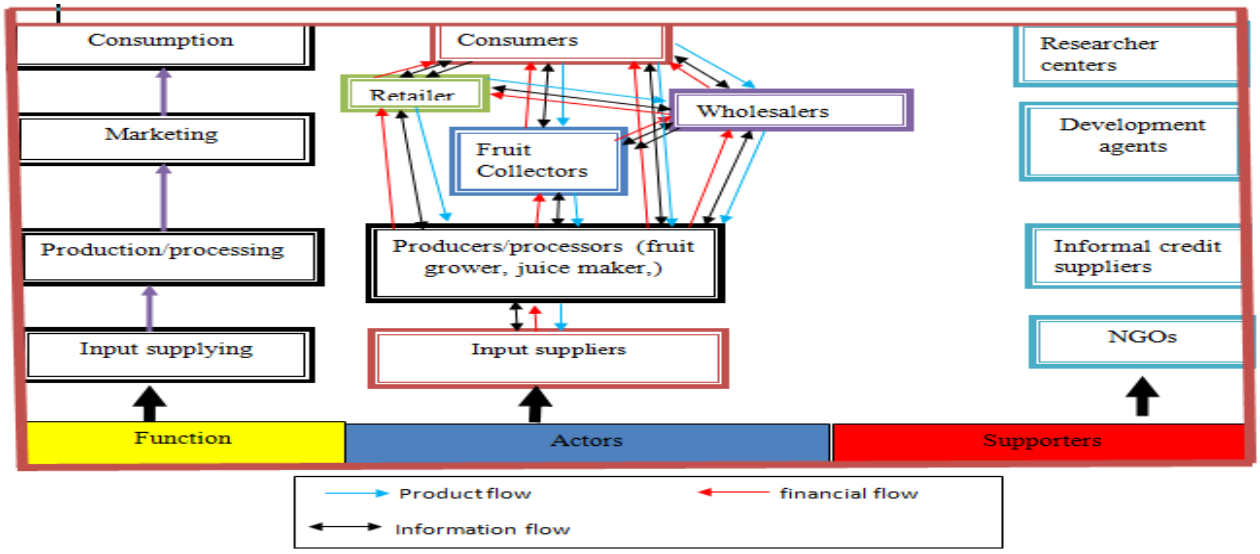

Figure 1.1. 3: Map of the avocado value chain (Source: Selamawit et al., 2019)

The avocado value chain is still at its infancy, with the majority of avocados being sold in the local markets or exported in raw state. As of 2020, the country has begun exporting avocados. Figure 1.7 illustrates the exported avocado fruits from Ethiopia, along with their annual monetary value, revealing a notable upward trend in export value.

Typically, the fruit is sold ungraded at local, zonal, and Addis Ababa markets, and is also shipped to neighboring countries ungraded. Graded and packaged avocados are exported to the UAE, the UK, the Netherlands, and other EU countries. Over the past five years, Ethiopia has been exporting fresh avocado fruits to the Gulf Countries including Bahrain, Djibouti, Saudi Arabia, Somalia, and the UAE, as well as to European countries such as Belgium, France, Netherlands, Spain, Sweden, and the United Kingdom. Exporting to the highly competitive markets of the European Union necessitates compliance with a series of stringent food safety standards, which include obtaining an ISO 9001 certificate, as well as adhering to requirements related to fresh fruits and vegetables, such as Hazard Analysis and Critical Control Point (HACCP) and traceability.

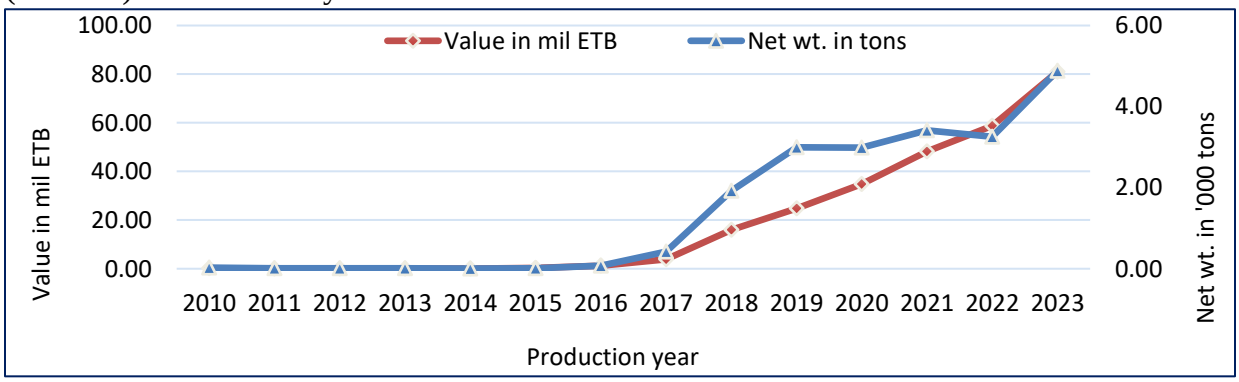

Figure 1.1. 4: Ethiopian export trend with corresponding monetary value
Source: Ethiopian Custom Authority

On the other hand, the demands for avocados have surged dramatically across various regional states and cities in Ethiopia. The domestic consumption of avocados is not only substantial but also on the rise annually, establishing it as a staple food in major growing areas as well as in urban areas. With the increased urbanization and rising incomes, demand for avocados is predicted to rise in Ethiopia, opening up prospects for value addition, such as higher quality and more variety of products.

In terms of processing potential, Ethiopia has established several facilities within the four Integrated -Agro-Industry Parks designated for agro-processing including avocado packhouse and avocado crude oil processing for export (Figure 1.1.5). These Integrated -Agro-Industry Parks (IAIP) are connected to all weather roads with some also connected to Dry Ports Infrastructures and Railways. Some of the IAIPs offer comprehensive services and facilities such as refrigerated container, inland transport, cold truck transport services essential for both avocado value-added packaging and oil processing (CodePixar, *Dry Ports of ESL* 2024; WFP Ethiopia Supply Chain Team, 2024).

Although avocado production in Ethiopia holds considerable promise, it faces significant challenges due to multiple factors throughout the value chain. These include the predominant reliance on local types, with more than 95% of the production derived from planting un-grafted seedlings, use of low-quality seedlings, poor field establishment, poor field management practices- such as poor irrigation and water management (Abera *et al.*, 2024), as well as inadequate attention to nursery operations and soil fertility management (Dejene *et al*., 2024; and Zeyede et al., 2024). Furthermore, prolonged gestation period to bear fruits or a complete failure to do so, poor fruit retention, inadequate knowledge of agronomic practices, limited access to improved varieties, the prevalence of insect pests and diseases, lack of a structured market, inadequate extension services, small landholdings, climate change, and drought. The situation is further aggravated by poor harvesting, postharvest, and careless handling practices during the transportation and marketing process (Hofman et al., 2012), ultimately leading to significant losses and the delivery of unsafe fresh fruits to consumers (Abebe, 2022).

1.2. Avocado Postharvest Loss

Postharvest loss refers to a measurable reduction in foodstuffs that can be categorized into quantitative and qualitative dimensions. Quantitative losses refer to mass or volume, where losses reduce the amount of produce available for consumption, which are commonly expressed in units of weight, monetary value (currency), and energy value (calories) though often reported in percentage. Qualitative losses relate to decreases in edibility, nutrition, caloric value, safety issues, and consumer acceptability, and ultimately affect the economic value of the produce before the produce is discarded, consumed, or repurposed. Overall food losses pose a serious threat to food, nutrition, and income security for many households, while simultaneously driving up food prices by diminishing the quantity of food in the supply chain. Moreover, such losses can imply loss of natural resources and inputs used for production of the food, while contributing to Greenhouse Gas (GHG) emissions.

Postharvest loss of avocados in Ethiopia is a significant concern for the industry. As a climacteric fruit, the avocado experiences heightened respiration and ethylene production (80 to 100 µL L-1) accompanied by biochemical changes (Bill *et al*., 2014), resulting in a continuous ripening post-harvest. Most of the studies on Avocado PHL reported by the FAO FLW database and HPEA (2014) described a mismatch in supply and demand or cosmetic and quality-related

issues as the main causes of PHL. Avocado postharvest deterioration can arise from poor harvesting practices including mechanical damage, chilling injury, soft landings, inconsistencies in ripening, and immature fruit picking, leading to decay; use of inappropriate packaging and limited access to controlled storage conditions, and poor transportation.

While the avocado value chain and its associated constraints have been relatively well studied in Ethiopia, data on avocado losses in the postharvest supply chain is scarce, and critical loss points remain less known. Furthermore, the lack of a standardized methodology for assessing postharvest losses, and thus uncertainty regarding the magnitude of these losses, is impeding the required focus that this issue warrants. To date, there are over 20 methodologies developed and tested to quantify FLW of different ranges of commodities along the food supply chain (FSC). However, these methodologies were developed targeting different users and providing different sets of information for informed decision-making and it appears that there is no one-size-fits-all FLW quantification methodology to be adopted by different FSC actors.

Often, postharvest food loss assessment methodologies included surveys using unstructured questionnaires, open-ended interviews, and focus group discussions. The quality of data generated from these approaches can be inconsistent, largely depending on the researchers' expertise in survey tool development. Objective measurements, also called direct measurements, through sampling of the produce at any particular segment of the supply chain are more appreciated for the level of accuracy. However, their application is seldom seen due to the extensive time and resources they necessitate.

PHL studies in Ethiopia hardly address qualitative losses, and as a result, qualitative PHLs at farmers, wholesalers, retailers, packers/traders, and transporters levels have been reported missing in Ethiopia. PHLs expressed as percentage or volume can often hardly indicate the impact of the problem unless they depict monetary impacts and negative consequences on food and nutrition security. On the other hand, only a few studies reported PHLs in terms of nutrition or calories (FAO, 2015), and Greenhouse Gas (GHG) emissions.

This study was carried out to address the aforementioned methodological gaps and generate comprehensive data on post-harvest losses in the avocado value chain, alongside an examination of the relevant pre- and post-harvest handling practices that lead to such losses. This information will be instrumental in developing strategies to enhance the competitiveness and sustainability of the avocado sector in Ethiopia.

1.3. Objectives of the Study

The objectives of the study were the following:

1) Determine the magnitude of avocado losses and identify critical loss points in the harvest and post-harvest supply chain, as well as their major causes and drivers.
2) Determine the economic impact of harvest and postharvest losses along the avocado supply chain as a decision-making input.
3) Assess the suitability of the "Customized Food Loss and Waste (FLW) Quantification Methodology" used in this study's postharvest loss assessment and make recommendations to stakeholders involved in the systematic measurement and reporting of food loos for possible adoption in avocado and other food crops.

4) Improve awareness, knowledge, and skills of key stakeholders involved in the identified avocado post-harvest critical loss points for better product handling and management.

1.4. Scope of the Study

This study aims to investigate the post-harvest losses of avocados from the point of harvest to the retail level. While it will address various pre-harvest factors that may lead to post-harvest losses, it will not cover losses that happen before harvest, those that occur at the consumer stage or nutritional losses that occur at each supply chain, and loss of internal quality and sensory qualities.

2. METHODOLOGY

2.1. Description of the Study Areas

The study was conducted across six major avocado-growing regions in Ethiopia including Oromia (Modjo), South West Ethiopia (Kaffa), South Ethiopia (Wolaita), Sidama (Yirgalem), Central Ethiopia (Silte) and Amhara (North Gojjam). The altitudes of these study areas range from 1400 to 1900 meters above sea level, exhibiting significant climatic variations among the sample study areas (Figure 2.1.1).

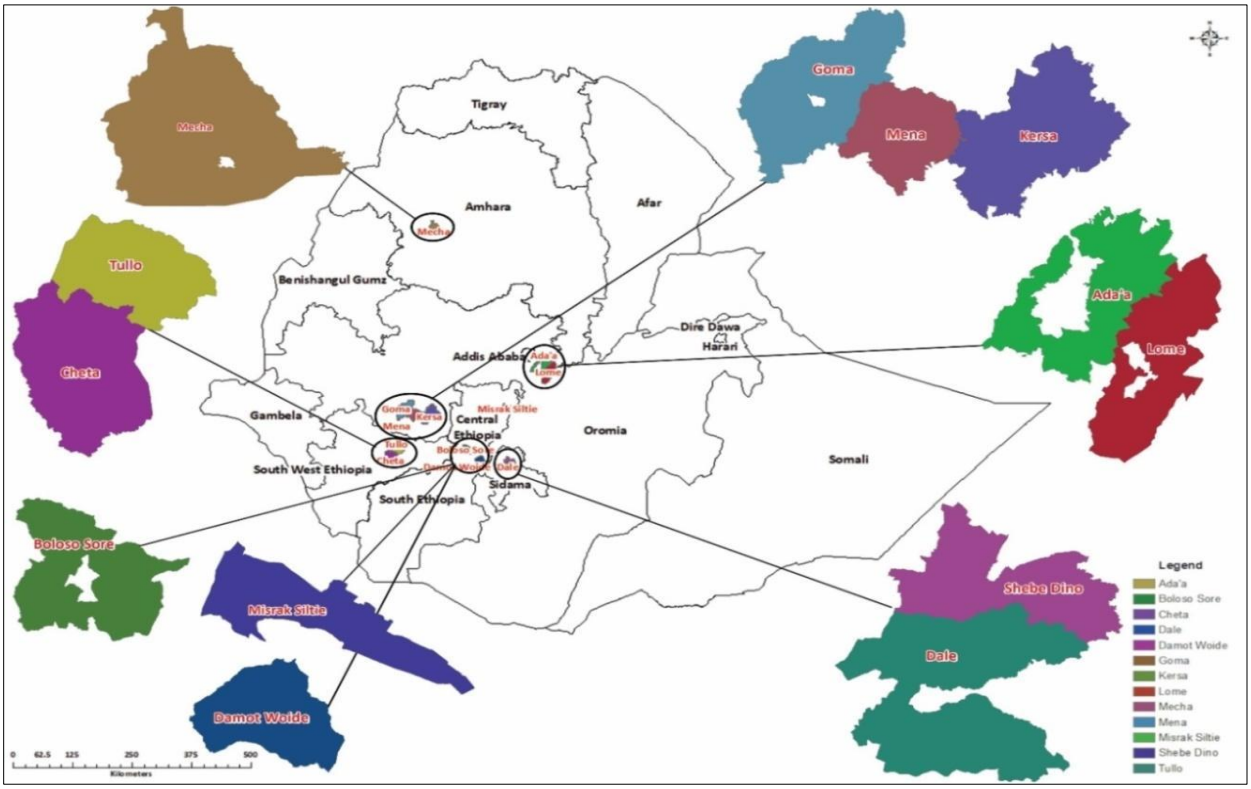

Figure 2.1. 1: Map of the study Woredas (Districts)

2.2. Sampling and sample size determination

S**ample size determination-** The study employed a multistage sampling technique to determine the sample size for a defined population group. Given that the most recent and accurate population proportion is not readily available for the issue of interest (farmers facing significant losses), the maximum default value p=0.5 (50%) was used to estimate the maximum possible sample size. The sample size of the individual respondents was thus estimated using the formula:

$$\sqrt{n = D \frac{Z^2 P (1-P) N}{ME^2 (N-1) + Z^2 P (1-P)}}$$

Where:

n = sample size;

Z = the critical value of the normal distribution at α/2 for a confidence level of 95%, i.e., 1.96;

ME = margin of error, i.e., 5%;

P = the anticipated proportion of respondents with the attribute of interest, estimated at 50% (.5) for a maximum effect;

Q = 1-P;

N = population size;

D = design effect, i.e., 1.5

Sampling technique - The sample selection process employed a multi-stage sampling approach that incorporated both purposive and random sampling methods. Initially, purposive sampling was utilized to identify six regional states known for their potential in avocado production and marketing: Oromia, Amhara, South Ethiopia, South West Ethiopia, Sidama, and Central Ethiopia. In the subsequent stage, key avocado-producing Administration Zones were chosen, as detailed in Table 2.1.1. The third stage concentrated on pinpointing avocado-producing Districts (Woredas) within each selected zone. From each District, 2 to 3 prominent avocado-producing Kebeles were randomly selected. Finally, individual farmers were randomly selected from the roster of avocado producers within the chosen Kebele administration, resulting in a total of 391 avocado producer farmers participating in the individual household survey. For the key informant interviews, 72 informants were purposively selected from various stakeholders in the value chain and support organizations, including wholesalers, retailers, exporters, researchers, and agricultural extension service providers, as illustrated in Table 2.1.2.

The data gathering was conducted across three predominant avocado production systems within the study regions: the cluster (commercial) avocado production system, the local avocado type production, and the mixed type, which encompasses both cluster and local varieties of avocado production (Tables 2.1.1). Generally, the avocados sampled from East Shewa, North Gojjam, and Silte Zone were solely of the grafted Hass commercial variety. In contrast, the avocado trees found in Jimma and Kaffa were un-grafted seedlings originating from unidentified segregating seeds. Meanwhile, the avocados from Sidama and Wolaita included both the grafted Hass variety and a significant number of trees derived from seeds.

Table 2.1. 1: Number of sample producers participated in the survey.

Region	Zone	Number of sample avocado producers	Frequency		
			Cluster	Local	Mixed
Oromia	East Shewa	47	47	-	-
	Jimma	82	-	82	-
Amhara	North Gojjam	49	49	-	-
Sidama	Central Sidama	38	-	-	38
	Northern Sidama	35	-	-	35
South West Ethiopia	Kaffa	42	-	42	-
Central Ethiopia	Silte Zone	39	39	-	-
South Ethiopia	Wolaita	59	-	-	59
Total		391	135	124	132

Table 2.1. 2: Number of KIIs conducted across the value chain

List of Actors	Number of KIIs conducted
Wholesalers	11
Retailers	17
Exporters	8
Researchers	20
Regional experts	15
EHPEA	1
Total	72

2.3. Study Design and Approach

The study employed a cross-sectional design using qualitative and quantitative data collection methods to capture the demographic and socio-economic characteristics and the physical and economic losses of avocado fruits. Primary and secondary data were extracted from target respondents and secondary data sources, respectively. The following are the main data collection methods employed during the assessment.

2.4. Data Collection

2.4.1. Document review

A comprehensive review of studies related to avocados postharvest loss in Ethiopia was undertaken, based on secondary data. The literature review focused on 24 recent assessments of postharvest losses published from 2014 to 2023, offering a concise overview of various loss assessment methodologies, the extent and types of losses, and the underlying causes of these losses.

2.4.2. Household survey

A household survey was conducted between mid-February 2023 and mid-January 2024, which included individual interviews with 391 avocado producer farmers located in 13 Woredas of six regional states of Ethiopia. The survey employed a mix of structured and semi-structured questionnaires to collect quantitative data pertaining to the demographic, socio-economic, and avocado production practices of the respondents. Questionnaires were prepared targeting avocado growers and other various actors supporting avocado developmen. Both qualitative and quantitative data were collected through Kobo Toolbox. The interviews were conducted in the local language of the study areas, recorded and subsequently transcribed into English for analytical purposes.

2.4.3. Key informant interview

Key Informant Interviews (KIIs) were carried out with 31 individuals who have in-depth knowledge and active engagement and supporting functions of the avocado value chain. The interviews utilized open-ended questionnaires and included a diverse group of participants: processors (2), researchers (10), exporters (3), regional agriculture experts (5), representatives from EHPEA (1), and 10 other participants contacted through telephone communication.

2.4.4. Direct observation

Direct observations were carried out in avocado orchards, marketplaces, transportation networks, and during the processing of avocado oil.

2.4.5. Validation, training, and awareness creation

A team of avocado professionals met on two separate occasions, once midway through and at the end, to evaluate and enrich the findings. Based on the findings of the study, a series of capacity-building training sessions were arranged for 197 key stakeholders in the value chain drawn from the study areas over four distinct sessions. Two awareness creation workshops were organized at Wolaita Sodo and Jimma towns to present the findings to key stakeholders from major avocado-growing regions.

2.4.6. Load-tracking based loss assessment

This study drew from the "Customized Food Loss and Waste (FLW) Quantification Methodology" put forth by FOLU and submitted to the Ministry of Agriculture. To assess postharvest losses of avocados, a combination of subjective and objective methods was utilized. The subjective method involved conducting interviews with a sample of respondents to collect their self-reported estimates at different points in the supply chain. The objective method, on the other hand, employed load-tracking, which involved direct measurements of product losses at each stage of the value chain. Estimation of quality and quantity losses was done at various avocado chain levels from the point of harvest to the point of retail.

With this method, data collection was carried out in the second week of September 2024 to objectively quantify the postharvest quality and quality loss of avocados along the domestic supply chain nodes by employing a load-tracking method in two locations, Bonga and Boditi. Over the course of five weeks, a team of researchers meticulously tracked the study from the production site to the final retail outlet. They performed direct observations and measurements, in addition to engaging with supply chain stakeholders to uncover the underlying causes of food losses and to explore possible solutions.

Table 2.4. 1: Locations and fruit characteristics of the load tracking study areas

Description	Bonga	Boditi
Agroecology	Wet, humid with a longer rainy season	Dry and shorter rainy season
Climate	A tropical monsoon climate (Köppen Am) with a short dry season in December and January and a lengthy (though not intense) wet season covering the remainder of the year	The wet season is mostly cloudy, the dry season is partly cloudy, and it is warm year-round
Fruit characteristics of avocados from Bonga and Boditi production areas		
Fruits size	Mixed local types, the majority of fruits are larger in size, with much thicker peel, larger pulp, and relatively smaller seed size	Mixed local types, the majority of fruits are smaller in size, have very thin skin, smaller pulp, and larger seed size as compared to the pulp
Fruits color	Mixed fruit colors (green, dark green, purple, and black)	Mixed fruit colors (green, dark green, purple, and black)
Fruits shape	Variable shapes (Oblate, spheroid, ellipsoid, narrowly obviate, obviate, pyriform and rhomboidal)	Variable shapes (Oblate, spheroid, ellipsoid, narrowly obviate, obviate, pyriform and rhomboidal)

Regarding sampling and data collection methodology, froilom the production areas of the two locations, three sample farmers were selected. The fruits were harvested using conventional methods and sorted according to the practices adopted by traders. Information related to the harvesting process and the qualitative and quantitative losses of the fruits was documented. Following this, three sample units, each weighing between 8 and 10 units, were extracted and stored in nylon net bags for continuous monitoring throughout each subsequent stage of the supply chain.

A systematic record was made of the quantitative and qualitative pH loss in avocado fruits at five specific stages of harvest and postharvest chain. These stages include the field harvesting stage (SC I), the loading onto trucks (SC II), the unloading at the wholesaler in Addis Ababa after transportation (SC III), the storage at the wholesale level before retailers made their purchases (SC IV), and the retail marketing stage (SC V), as presented in Table 2.4.2.

Table 2.4. 2: Data collected using a load-tracking technique

Value Chain Stage	Value Chain Node Activity	Data collected
SC 1	Harvesting	• Fruits that sustained total damage during harvesting and are designated for disposal • Fruits that experienced mechanical damage but can be sold later at a reduced price • Immature fruits that will not ripen subsequently • Total qualitative and quantitative losses
SC 2	Loading on tracks, and transportation from the harvesting field to storage/marketing / aggregation	• Total weight of tagged fruit samples arrived at the aggregation place • The physiological weight loss incurred during transit • The weight of fruits that were totally damaged and deemed unsuitable for sale • The weight of fruits with minor physical damages that can be sold at a reduced price • The estimated local price for less damaged fruits • Estimated price for sound fruits at a particular spot • Percentage of qualitative and loss • Percentage quantitative loss • Sound fruits moved on to the next supply chain
SC 3	Unloading to the central or destination markets	• Weight of samples after unloading • Percentage of physiological weight loss during transportation • Weight of completely damaged fruits during transportation • Weight of fruits with minor damages that can be sold in a reduced price • Local market price of fruits with minor damages • Weight of sound fruits samples from load tracking after transportation that can proceed to next supply chain; Local price of sound fruits after unloading • Percentage of qualitative loss; Percentages of quantitative loss • Total quantitative loss
SC 4	Storage at the wholesale level before retailers made their purchases	• Weight of sample fruits from load tracking after 80 % of the bulk sold, • Percent physiological weight loss • Weight of completely damaged fruits during wholesale trade • Weight of fruits with minor damages that can be sold at a reduced price • Local market price of fruits with minor damages • Weight of sound fruit samples can proceed to the next supply chain (retail market); the Local price of sound fruits at this stage • Percentage qualitative loss; Percentage quantitative loss • Total quantitative loss;
SC 5	Retail marketing	• Weight of sample fruits after transportation or final retail market destination • Percent physiological weight loss, • Weight of completely damaged fruits during retail marketing • Weight of fruits with minor damages that can be sold at a reduced price at the retail market; • Percentage qualitative loss, Percentage quantitative loss, Total quantitative loss

2.5. Data Quality Control

The individual household survey was using an e-data collection tool which was designed by Kobo toolbox e-data collection tool development software. Skip logic, mandatory responses, and other self-corrected data quality control mechanisms were used during the e-data collection tool design stage to assist the enumerators and reduce data collection errors. In addition, a careful selection of the enumerators was made by considering the educational level and prior experience of the enumerators in the data collection of similar studies. A thorough discussion was held with the enumerators to brief them on the contents of the data collection tools and data collection procedures ahead of the data collection. During the fieldwork, pretesting of the questionnaire was conducted using a few sample respondents ahead of the actual data collection and all efforts were made to conduct spot-checking and close supervision.

2.6. Data Analysis

Qualitative and quantitative data obtained from household surveys, key informant interviews, and secondary sources were subjected to analysis through descriptive statistics. As a result, information gathered from a sample of avocado producers and traders, along with field notes from a range of observations, was transcribed and subjected to analysis through SPSS software, which facilitated the calculation of mean, standard deviation, frequency, and percentiles. Responses to each of the questions in the questionnaires were triangulated with field observations, earlier reports, personal communications, and both published and unpublished documents, and compared against best practices of other avocado-producing countries for benchmarking purposes. The results are visualized through tables, bar charts, and graphs.

Physical losses were calculated in weight lost from one value chain stage to the next by subtracting the weight of crops discarded from the initial total weight of the crops. The quality loss was measured in monetary value, as the deviation from the potential best price of a product with the best quality. The total economic loss was measured as the percentage of total revenue lost due to physical and quality losses. Both loss of whole food and food depreciation (quality loss) were measured by the deviation from the best price, which is obtained for the best quality product at a given time.

3. RESULTS AND DISCUSSION

Desk review findings- in the process of reviewing available documents on the avocado postharvest loss assessment, several gaps have been identified. In Ethiopia, there is a notable lack of focus on the assessment of post-harvest losses. The data available on these losses is often inconsistent, primarily due to the application of non-standardized methodologies for post-harvest loss assessment. Furthermore, a significant portion of the studies rely on self-reported data and controlled laboratory experiments.

The lack of adequate experience and skills in the evaluation and reporting of postharvest losses (PHL) has resulted in data that is not disaggregated into qualitative and quantitative, often leading to aggregated reporting. There is also a significant gap in studies that investigate postharvest losses in the entire value chain. Only a handful of PHL studies trace a specific crop from the harvest stage through the food supply chain, measuring losses at various points, which makes it challenging to calculate total PHLs for the entire food supply chain. Moreover, there is a dearth of PHL studies that present data at critical loss points.

Furthermore, the underlying causes and factors that lead to postharvest losses are often insufficiently detailed. The impacts of PHL are not also comprehensively described. Reporting on PHL should extend beyond mere percentages or volumes of food lost, but also in terms of monetary value, food and nutrition security, environmental impact, volume of raw materials failed to fuel up industrialization and the country's development agenda.

3.1 Demographic and Socioeconomic Characteristics

3.1.1. Age of family head of avocado growers

The surveys revealed that nearly all age groups within the study regions engage in avocado production. There is a notable absence of youth family heads in avocado production within the North Gojjam and Kaffa Zones. Conversely, in the Northern Sidama region, there is a higher prevalence of youth family heads among growers. On the other hand, older farmers are most prevalent in the Jimma and Wolaita Zones (Table 3.1.1) indicating their deep-rooted involvement in local avocado production in Ethiopia.

Table 3.1. 1: Age category of sample smallholder respondents of avocado growers

Region	Zone	Age category (%)			
		<25	25-54	55 - 64	>64
Oromia	East Shewa	13.3	10.1	16.4	25.0
	Jimma	6.7	20.2	27.3	25.0
	Average	10.0	15.2	21.8	25.0
Amhara	North Gojjam	0.0	11.8	23.6	4.2
Sidama	Northern Sidama	33.3	9.1	3.6	4.2
	Central Sidama	26.7	9.8	5.5	8.3
	Average	30.0	9.4	4.5	6.3
South West Ethiopia	Kaffa	0.0	12.1	7.3	8.3
Central Ethiopia	Silte	13.3	12.5	0.0	0.0
South Ethiopia	Wolaita	6.7	14.5	16.4	25.0

Source: Computed from Survey Data, 2024

3.1.2. Education level of family head of avocado growers

The findings indicate that a large proportion of avocado producers (41%) in the studied areas are either uneducated or have not advanced beyond the 4th grade. North Gojjam has the highest illiteracy rate among farmers at 61.2%, followed by Sidama at 36%. One-third of the growers have reached an educational level between the 5th and 8th grades. In contrast, only one-fourth of the total growers possess education at the high school, college, or university level. This trend implies that a significant amount of avocado production is overseen by farmers who are less educated and skilled (Table 3.1.2).

Table 3.1. 2: Education level of smallholder avocado growers

Region	Zone	Level of education (%)						
		Illiterate	Grade 1- 4	Grade 5-8	Grade 9-10	Grade 11-12	TVET complete	University Graduate
Oromia	East Shewa	21.3	8.5	29.8	25.5	12.8	0.0	2.1
	Jimma	22.0	24.4	39.0	11.0	0.0	3.7	0.0
	Average	21.6	16.5	34.4	18.3	6.4	1.8	1.1
Amhara	North Gojjam	61.2	18.4	10.2	6.1	0.0	0.0	4.1
Sidama	N. Sidama	2.9	20.0	51.4	8.6	8.6	8.6	0.0
	Central Sidama	7.9	18.4	42.1	15.8	7.9	7.9	0.0
	Average	5.40	19.20	46.75	12.20	8.25	8.25	0.00
SW Ethiopia	Kaffa	16.7	26.2	38.1	11.9	2.	2.4	2.4
C. Ethiopia	Silte	10.3	25.6	38.5	20.5	5.1	0.0	0.0
South Ethiopia	Wolaita	25.4	20.3	20.3	16.9	5.1	8.5	3.4
Mean		22.5	20.5	32.7	14.3	4.6	3.8	1.5

Source: Computed from Survey Data, 2024

3.1.3. Growers' duration of engagement in avocado production

The study indicated that 68.6% of avocado growers are engaged in avocado production for a period of less than ten years. On the other hand, 31.5% of the growers, predominantly located in traditional local avocado-growing regions such as Kaffa, are engaged in avocado production for over 10 years (Table 3.1.3). Growers from North Gojjam, Silte and East Shewa are particularly new entrants to the avocado production as a result of the recent government promotional efforts for commercial production.

Table 3.1. 3: Experience of sample farmers in avocado production

Region	**Zone**	**Years of experience in avocado production**			
		< 5	6-10	11-15	>15
Oromia	East Shewa	21.3	44.7	21.3	12.8
	Jimma	3.7	56.1	35.4	4.9
	Average	12.5	50.4	28.3	8.8
Amhara	North Gojjam	26.5	69.4	4.1	0.0
Sidama	C. Sidama	5.3	44.7	39.5	10.5
	N. Sidama	5.7	60.0	20.0	14.3
	Average	5.5	52.4	29.7	12.4
S W Ethiopia	Kaffa	0.0	50.0	38.1	11.9
C. Ethiopia	Silte Zone	59.0	33.3	5.1	2.6
Overall Average		**17.4**	**51.2**	**23.4**	**8.1**

Source: Computed from Survey Data, 2024

3.1.4. Family size of smallholder avocado growers

According to the study, the majority of avocado growers have family sizes that range from 4 to 6 individuals, with Kaffa reporting the highest family size (7-9) with the largest proportion of sample respondents (52.4%) with this category of the family. Some 21.4% and 16.9% of the avocado growers in Kaffa and Wolaita had a family size of above 9 (Figure 3.1.1).

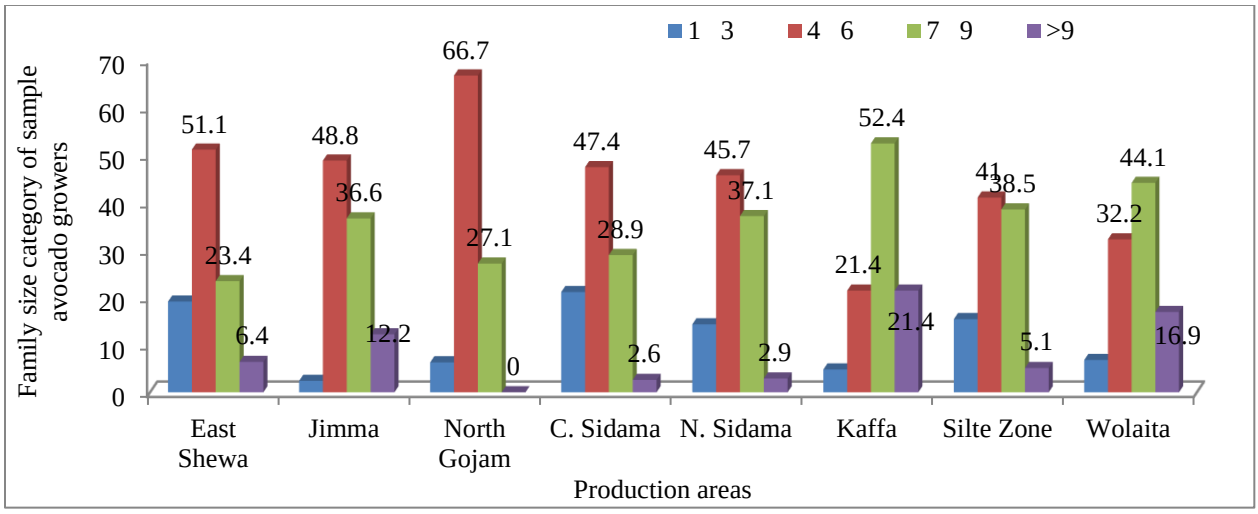

Figure 3.1. 1: Family size category of sample avocado growers

3.1.5. Purpose of avocado production by the smallholder farmers

The study revealed that there is a disparity among different zones and sample Woredas regarding the reasons for producing avocados. These reasons include home consumption, selling surplus produce at local village markets, and further selling any remaining excess at larger main markets. The findings indicated that 72.4%, 71.1%, and almost half (49.1%) of the growers reported that they grow avocados primarily for home consumption, for local fresh markets, and for both home consumption and fresh market sales, respectively (Figure 3.1.2).

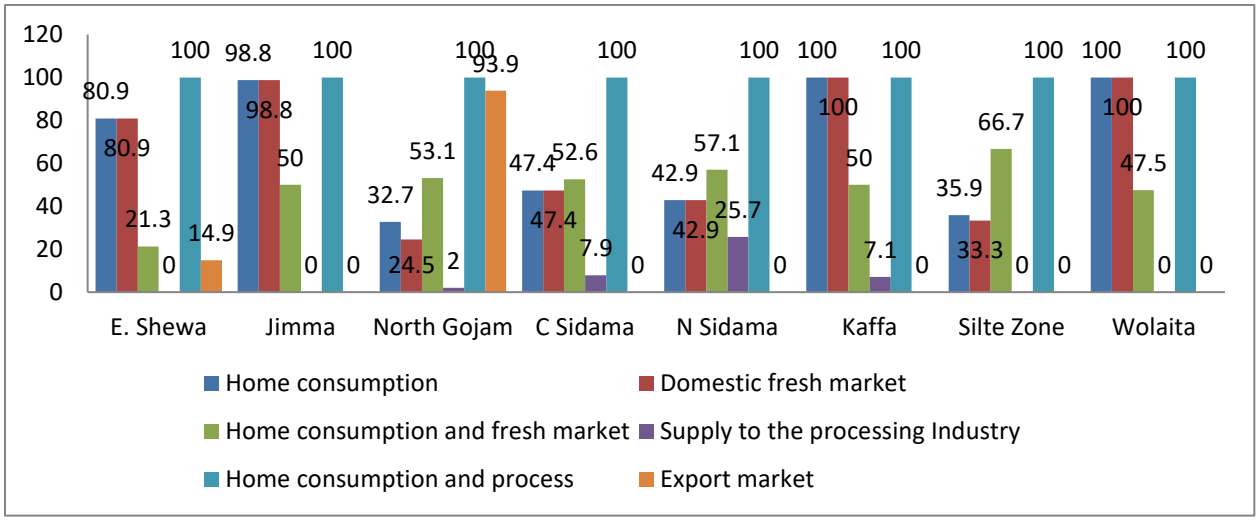

Figure 3.1. 2: Purpose of avocado production by the producers

As shown in Figure 3.1.3, the average home consumption of avocados stands at 14.2%, with Oromia leading followed by North Sidama and Wolaita, whereas North Gojjam has the lowest rate. This suggests that the home consumption of avocados in North Gojjam is significantly lower than that of the more established districts of Wolaita and Sidama. Avocado fruits are eaten with all types of food recipes in the Wolaita, Sidama, and Jimma areas.

On the other hand, on average 72.4% of avocado fruits are produced for domestic fresh markets in Ethiopia (Figure 3.1.3). The Central Sidama, Jimma, Silte, and Wolaita Zones produce more than 80% of avocado fruits for the fresh market.

In the study areas, on average, 11% of the produce was reported as exported in 2023. Although avocados are traditionally exported from East Shewa, North Gojjam, and Meskan, exporters currently collect and ship avocados from several locations, including Sidama, Jimma, West Wollega, Buno Bedele, and Illuababora. North Gojjam exports 73% of avocados, with East Shewa accounting for 14% (Figure 3.1.3).

A small fraction, approximately 2.4%, of the total avocado production is utilized for oil processing. The data reveals that 11.2%, 5.3%, 4.7%, and 1.2% of avocado growers in Northern Sidama, Central Sidama, Kaffa, and Wolaita, respectively, reported supplying their avocados for oil processing (Figure 3.1.3).

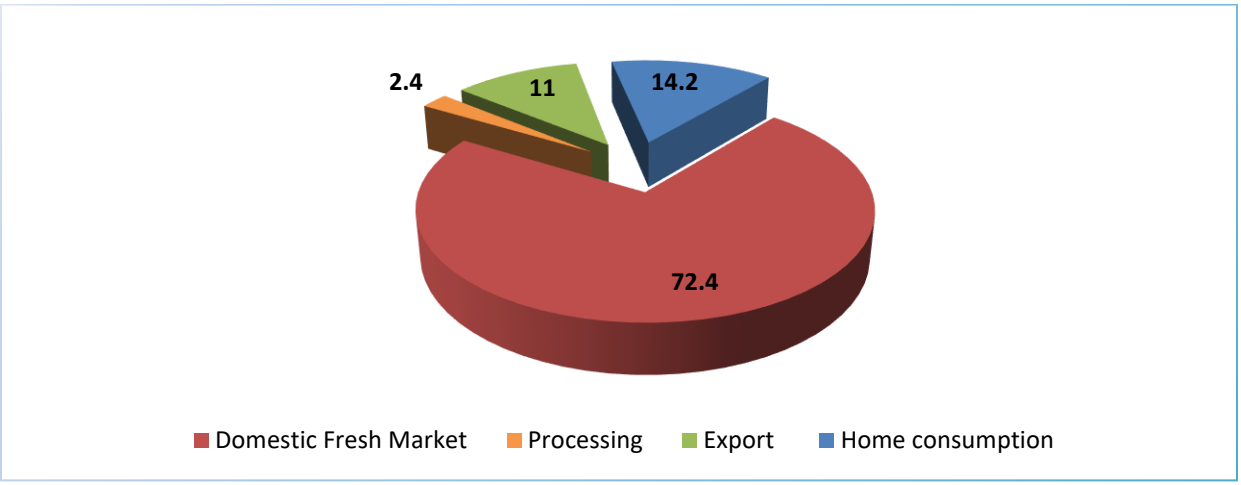

Figure 3.1. 3: Purpose of avocado fruits by avocado producers in 2023

Pertaining to the purpose of avocado production, it is noteworthy to mention the practice of harvesting immature avocado fruits, commonly referred to as "Chuuloo" (ጨሉ). In the past, local avocado varieties in the Jimma and Kaffa Zones were not able to mature, leading to their harvesting in an immature state during the months of February and March. In recent times, however, the practice of harvesting immature avocados has gained popularity for local industrial purposes, commonly referred to as "Chuuloo" ጨሉ. Traders and transporters purchase these immature fruits to produce dye used for walls and furniture paints. Harvesting immature avocado fruits for this purpose enables the avocado trees to bloom after each harvest. Nonetheless, the benefits and drawbacks of harvesting young avocados, as well as the corresponding tree phenology, should be thoroughly studied.

3.1.6 Estimated total annual income of avocado growers

Estimation was made regarding the total annual income of the sample avocado farmers, including their annual income specifically from avocado fruits, categorized by cluster, local type, and mixed avocado producers.

The results indicated that the average estimated annual total income for commercial avocado growers is 439,597.50 Birr. The highest average income reported was 721,194.7 Birr per year in East Shewa, whereas the lowest average income was found in the Silte Zone, which stood at 242,687.2 Birr per year. Furthermore, certain avocado growers in East Shewa reached an impressive maximum income of 5.4 million Birr in the 2023 production year.

The annual average income for local avocado growers was found 123,884 Birr with the highest average income of 134,328.6 Birr in Kaffa and the lowest average income of 113,439.4 Birr in Jimma. Jimma stands out with a maximum reported income that can reach as much as 3 million Birr per year. Among mixed avocado growers, the estimated annual average income was found 116,649.4 Birr, which ranges from 77,729.1 Birr in Wolaita to 175,144.70 birr in central Sidama, with the latter reaching a maximum of 1 million birr per household per year. The production of avocados in the Wolaita Zone is entirely reliant on seasonal rainfall. When there is some precipitation during the typically prolonged dry season, it results in improved yields in the subsequent years. In general, the total annual income for improved clustered avocado growers surpasses that of both local and mixed avocado farmers.

3.1.7. Estimated annual income of avocado grower from avocado

The contribution of avocado income to the overall household income varied, accounting for 22-38% for improved/cluster growers, 18-46% for local growers, and 44-47% for mixed avocado growers (Table 3.1.4).

The study indicated that within the sampled regions cultivating the Hass variety (commercial), East Shewa generates the highest average annual income of 156,602.00 birr from avocado fruit sales, with a maximum income reaching up to 2,300,000.00 birr per year. This is followed by the Silte Zone, which earns an average of 93,228.00 birr annually from avocado fruit sales. The Hass avocado is preferred by consumers due to its superior taste and flavor, while oil processors favor it for its lower fatty acid content. Additionally, transporters, wholesalers, and retailers appreciate its extended shelf life.

The estimated annual income derived from local avocado varieties in the Jimma and Kaffa zones varies considerably, with figures ranging from 20,224.00 Birr per household in Jimma to 61,179 Birr per household in Kaffa. A considerable number of avocados is harvested for household use, and women engage in selling these fruits on a daily or weekly basis to support household expenses, including those related to their children's education. However, many farmers do not incorporate these sales into their total harvest reports, which can skew income assessments. In general, farmers who possess a greater number of avocado trees tend to report higher estimates of annual income. In the 2023 production year, the annual income of mixed avocado variety (Hass and local types) growing farmers varied from 36,819 Birr in Wolaita to 77,153 in Central Sidama (Table 3.1.4). Generally, farmers cultivating commercial clustered avocados experience a higher annual income compared to those engaged in local and mixed avocado growing.

Table 3.1. 4: Total estimated annual and avocado-derived income of avocado growers

Region	Zone	Annual income from all income sources (Birr)				Annual income from avocado production (Birr)				% total mean income
		Mean	Std. Dev	Minimum	Maximum	Mean	Std. Dev	Minimum	Maximum	
Improved cluster production										
Oromia	East Shewa	721,194.70	1,077,107.30	30,000.00	5,400,000.00	156,602	383378	5,000	2,300,000.00	21.7
Amhara	N. Gojam	354,910.60	657,311.30	120	3,000,000.00	88,174	123865	30	540,000.00	24.8
C Ethiopia	Silte Zone	242,687.20	363,961.90	21,000.00	2,294,000.00	93,228	106175	1000	460,000.00	38.4
Local avocado										
Oromia	Jimma	113,439.40	329,304.20	30	3,000,000.00	20,224	24394	0	130,000.00	17.8
SW Ethiopia	Kaffa	134,328.60	166,627.50	15,000.00	784,000.00	61,179	92241	1000	500,000.00	45.5
Mixed (improved -Hass variety and local)										
Sidama	C. Sidama	175,144.70	174,371.50	22,000.00	1,000,000.00	77,153	81773	1800	300,000.00	44.1
	N. Sidama	97,074.30	80,354.30	9,000.00	450,000.00	38,266	29869	2000	98,000.00	39.4
S Ethiopia	Wolaita	77,729.10	68,491.70	15	285,000.00	36,819	35664	500	144,000.00	47.4

3.1.8 Importance of avocado fruits in gender and family livelihoods

In households where avocado trees are grown, food shortages are virtually nonexistent, as these trees play a crucial role in securing the family's food supply. At present, there is no need to sell grains to meet various expenses incurred by either spouse, as many avocado growers have indicated that all grains are utilized for family consumption. The income generated from avocado sales sufficiently covers the family's annual expenses. This has also alleviated the burden on women, who no longer need to request money from their husbands for various expenditures; they often carry some avocados with them when they go to the markets. The avocado fruit stands out as an important cash crop actively traded in local and rural markets in all avocado-growing areas. The markets serve as collection points for the fruits which are then transported to the central markets (Figure 3.1.4).

Figure 3.1. 4: Avocado collection and marketing by the avocado producers

Many avocado growers replied that they do not possess accurate information about the annual yield and income associated with avocado production. This is primarily because most wives regularly take portions of the avocado harvest to the local markets for selling which allows them to purchase essential items for their household kitchens (Figure 3.1.5). This practice is very common in areas where local avocados are widely grown such as Jimma, Kaffa, Wolaita, and Sidama production areas. Furthermore, a significant number of women respondents expressed those avocados are multifunctional resources for their households. The income generated from

the sale of these fruits is allocated to meet all educational costs for students, encompassing uniforms, stationery, and fees at every educational level.

Figure 3.1. 5: Women in rural areas in the avocado business

3.1.9. Avocado fruits in the family food system

Avocado is a versatile fruit that has been produced for its flavor, nutritional value, and socio-economic and multipurpose benefits in Ethiopia. Once regarded as an exotic fruit, it has now been integrated into the daily diet, driven by the increasing demand for natural products.

Avocado is recognized as a highly nutrient-dense fruit (Boost *et al*., 2012) that is available year-round in areas such as Sidama, Wolaita, and many other growing areas of Ethiopia. In these areas, every farmer grows local avocado trees alongside coffee, Enset, and other perennial and annual crops within their homesteads. With basic management practices, they are reaping significant avocado harvest each year from local avocado varieties. Consequently, smallholder farmers and urban residents in locations like Boditi and Sodo in the Wolaita Zone, as well as other avocado-producing regions, have developed a range of culinary recipes and diverse methods of utilizing the fruits at households and street food vendors' level. The food items include avocado juices, avocado paste, foul mudamas, salad and an array of side-dressing recipes showing the nutritional opulence of the family. The ripe avocado fruit is often enjoyed with bread and other food items like by mixing raw avocados with boiled root crops etc. as part of breakfast, lunch, and dinner. It is also meshed with other herbs and spices and utilized during lunchtime or snack time (Figure 3.1.6). Women respondents in some of the avocado growing areas reported that during the harvesting seasons children pick avocados and eat raw with bread or without. In some areas women use avocados for hair treatment and as body lotion.

Figure 3.1. 6: Avocado fruit with varieties of recipes at Wolaita Sodo

Avocado has already a large market and is sold as a fresh fruit for side dressing, sole, and mixed juices (Figure 3.1.7). Avocado juice, whether served alone or mixed with other fruits, is very common across all towns, cities, and rural production areas of Ethiopia, where one can find numerous juice houses, bars, and restaurants (Figure 3.1.7). Avocado is commonly paired with tomato sauces, onion, potato, etc. and is locally known as Panchera (evening fast food option along the roadside) contributing to the nutritional opulence of the people (Figure 3.1.8).

Figure 3.1. 7: Variety of avocado juice (sole or mixed with other fruits

Figure 3.1. 8: Panchera (Street vendor evening fast food) and avocado salads

Some female respondents living around cities and towns in Jimma and Bonga town replied that they sell ripened avocado fruits all the time rather than selling unripe fruits at once in bulk. The price for a single ripe avocado fruit ranges from a minimum of 10 Birr to a maximum of 20 Birr.

3.2: Pre-harvest Management of Avocados

The maximum quality of fruit is primarily influenced by pre-harvest management practices, harvesting techniques, and postharvest systems. Greater knowledge and understanding of these interactions are imperative to address the complex issues related to high-quality fruit production and marketing. There is a growing awareness of the interactions between all parts of avocado production and postharvest systems about fruit quality across the globe (Hofman et al., 2012).

The production of high-quality fruit begins well before planting good-quality grafted avocado seedlings from commercial varieties. It involves careful selection of soil, thorough field preparation, ensuring soil fertility and adequate irrigation, as well as managing weeds, pests, and

diseases. Additionally, weather conditions and other management decisions play a crucial role. The harvest marks the culmination of cultivation and the beginning of post-harvest actions, during which preparation for market readiness and distribution is undertaken through the various stages of the supply chain.

3.2.1. Management of avocado orchards

Almost all farmers in the Jimma, Kaffa, Wolaita, and Sidama areas possess many avocado trees that have been raised from seeds and thrive under rainfed conditions without the need for supplementary irrigation (Figure 3.1.9). It is very rare to find a homestead without avocado trees. On the contrary, in the East Shewa Zone, avocado production is predominantly based on commercial varieties that are grown with r irrigation during the prolonged dry season.

Figure 3.1. 9: Seedling avocado trees in the homesteads grown from seeds in Kaffa

The majority of sample farmers grow their avocado trees in orchards and plantations using traditional methods, characterized by unrestricted growth and development for nearly four years, without the application of irrigation or nutrients. While individual trees exhibit diverse bearing habits and fruit characteristics, certain seedling trees have been known to produce fruit for over 50 years in regions such as Sidama and Wolaita Zones.

A considerable number of farmers have established a large population of avocado trees from seeds within their homegardens and surrounding locales. Conversely, the establishment rate of commercial varieties is quite low, resulting in a limited number of Hass and Ettinger trees across all sampled locations. This situation is primarily due to the lack of proper management for young trees, such as the provision of irrigation and nutrient application.

Most of the local (mixed) avocado varieties found in markets generally display poor quality characteristics including a) varying degrees of maturity, with many fruits being immature, b) inconsistent firmness, c) a lack of uniformity in size and shape, and d) skin defects along with diverse flesh discoloration. Moreover, the thin skin of these avocados increases their susceptibility to damage and enhances their perishability throughout the supply chain for several reasons. Despite this, almost all avocado producers in the sampled areas are familiar with commercial avocado varieties, which are known for their early bearing, short stature, and narrow canopy, making them suitable for export.

3.2.2. Avocado varieties in the smallholder production system

Growing avocado trees from seeds is a straightforward and prevalent practice, particularly in regions with high rainfall, such as Jimma, Kaffa, and other areas in Southwestern Ethiopia, where the population of these trees is substantial. While the characteristics of the fruits produced by local trees can differ significantly from one tree to another, the overall yield per tree is

remarkably high, leading farmers to favor planting avocados from seeds. Conversely, from the viewpoint of farmers, grafted avocado seedlings are considered quite costly due to the significant inputs they necessitate; Ethiopia currently has six registered varieties of avocados, in addition to a wide array of local tree varieties cultivated by smallholder farmers. A considerable number of these farmers prefer the indigenous avocado types, as they appear to be more resilient to stress and offer higher yields. Therefore, many avocado producers in the Jimma, Kaffa, and Wolaita Zones have favored the planting of seedling avocado trees, and thus the production of trees from segregated un-grafted sources is a common practice in these areas.

On the other hand, commercial avocado varieties (Hass and Ettinger) are frequently encountered in regions where cluster avocado production is practiced, particularly in North Gojjam, East Shewa, and Silte, as well as in smaller areas in Jimma, Wolaita, and Sidama. The leading commercial variety is Hass, with a prevalence of 58.3%, followed closely by Ettinger at 54.7%. In contrast, more than half of the avocado tree populations in the Kaffa Zone are represented by local and mixed varieties. The Wolaita Zone has 47.5% of its trees as local types, while Jimma areas show 34.9%, and Sidama has 31.2% of its trees classified as local (Table 3.2.1).

Table 3.2. 1: Local and grafted avocado varieties under production by the smallholder farmers

Region	Zone	Type of varieties (%)							
		Local	Hass (A)	Fuerte (A)	Bacon (B)	Ettinger (B)	Pinkerton (A)	Nabal (B)	Others
Oromia	East Shewa	14.9	80.9	14.9	6.4	72.3	6.4	4.3	17.0
	Jimma	54.9	14.6	1.2	0.0	7.3	0.0	0.0	40.2
	Average	34.9	47.7	8.1	3.2	39.8	3.2	2.1	28.6
Amhara	N. Gojjam	0.0	100.0	0.0	0.0	98.0	0.0	2.0	0.0
Sidama	C. Sidama	39.5	94.7	73.7	57.9	97.4	39.5	47.4	0.0
	N. Sidama	22.9	80.0	22.9	11.4	82.9	8.6	45.7	8.6
	Average	31.2	87.4	48.3	34.7	90.1	24.0	46.5	4.3
SW. Ethiopia	Kaffa	50.0	11.9	0.0	0.0	9.5	0.0	0.0	47.6
C. Ethiopia	Silte	33.3	71.8	0.0	0.0	66.7	0.0	2.6	20.5
South Ethiopia	Wolaita	47.5	54.2	0.0	0.0	50.8	1.7	0.0	25.4
Average		35.0	58.3	11.3	7.4	54.7	5.6	9.7	22.3

Source: Computed from Survey Data, 2024

Many avocado growers have reported that the Hass variety features a thick skin that is not easily damaged, unlike local types. Additionally, it will take a long time from 7-20 days for ripening. Nevertheless, the yield of Hass trees, when grown without irrigation or adequate nutrition, is quite low, falling below 100 kg per tree per year, particularly when compared to Ettinger and local varieties. In the Wolaita zone, both Hass and Ettinger growers have noted that the Ettinger variety exhibits a significantly higher yield, prompting many farmers to favor the planting of Ettinger avocados.

In contrast, the avocado fruits from the local trees examined in the study exhibit thin skin, making them prone to damage during harvesting and transportation. The majority of farmers and traders indicated that avocados from local trees typically ripen within a span of three to four days. This rapid ripening process complicates the handling of locally sourced avocados.

Consequently, harvested avocados must be promptly transported to collection centers. Transporters commence their journeys at night, ensuring that the loaded trucks arrive at the central fruit and vegetable markets in Addis Ababa by early the following morning.

On average, 66% of avocado producers indicated that they do not utilize grafted varieties. However, in regions with high rainfall, such as Jimma and Wolaita, many smallholder farmers maintain both grafted and ungrafted avocado trees, despite a considerable number of local varieties. A survey conducted in North Gojjam Zone revealed that 98% of the sampled growers have adopted grafted commercial varieties. Most respondents who grow grafted seedlings are located along paved or all-weather gravel roads, while those situated farther from these routes tend to plant avocado seeds instead of grafted trees. Inadequate road access can hinder the marketing of avocado produce, which is often bulky and highly perishable.

3.2.3. Avocado tree population per grower and by variety

The number of avocado trees cultivated by each grower, regardless of the variety, varies significantly, ranging from a few trees to over 700 in different locations. Commercial growers typically maintain a larger number of trees, often on the higher end of this spectrum. However, the commercial avocado growers within the cluster areas exhibit a diverse range in the number of trees grown. Approximately 4% of the sampled farmers maintain over 700 trees. In the East Shewa Zone, a significant majority (70.2%), of the sampled farmers possess fewer than 100 trees. Conversely, in North Gojjam Zone, the predominant category of commercial avocado growers (53.1%), has between 100 and 300 trees (Table 3.2.2). Likewise, a significant proportion of the surveyed farmers, 95.1% of local avocado growers in the Jimma Zone and 81% in the Kaffa Zone, possess fewer than 100 avocado trees (refer to Table 3.2.2). Overall, 87.6% of the mixed-type avocado growers had less than 100 avocado trees. Among avocado growers engaged in mixed-type avocados, 98.3% in the Wolaita Zone have fewer than 100 trees, while growers in Central Number of avocado trees per grower by avocado variety categories

Table 3.2. 2: Number of avocado trees per grower by avocado variety categories

Cluster avocado growers						
Region	Zone	Number of avocado trees owned by the farmers (%)				
		<100	100-300	300-500	500-700	>700
Oromia	East Shewa	70.2	10.6	6.4	6.4	6.4
Amhara	N. Gojjam	30.6	53.1	6.1	4.1	6.1
C. Ethiopia	Silte Zone	94.9	5.1	0.0	0.0	0.0
Average		65.2	22.9	4.2	3.5	4.2
Local avocado growers						
Oromia	Jimma	95.1	4.9	0.0	0.0	0.0
SW Ethiopia	Kaffa	81.0	11.9	4.8	0.0	2.4
Average		88	8.4	2.4	0.0	1.2
Mixed type avocado growers						
Sidama	C. Sidama	71.1	18.4	7.9	0.0	2.6
	N. Sidama	97.1	2.9	0.0	0.0	0.0
	Average	84.1	10.6	3.9	0.0	1.3
S. Ethiopia	Wolaita	98.3	1.7	0.0	0.0	0.0
Average		87.65	8.4	3.0	0.0	1.0

Source: Computed from Survey Data, 2024

When considering only fruit-bearing trees, commercial avocado growers have 113 trees on average. North Gojjam has an average of 188 trees per grower, representing the highest figure among the commercial avocado growers, in contrast to the Silte Zone, which has the lowest number of fruit-bearing avocado trees, 32 per grower. On average, 32 fruit-bearing avocado trees were available per farmer among the mixed avocado tree growers. Central Sidama demonstrates the highest average (86) mixed-type fruit-bearing avocados, in contrast to the Wolaita Zone, which has the lowest average of just 14 bearing trees. This indicates that the presence of mixed-type avocados leads to significant variability in the fruit-bearing stage, which in turn impacts synchronized production—a crucial factor for effective marketing (Table 3.2.3).

Table 3.2. 3: Number of avocado trees bearing fruits in each smallholder farmers

Commercial avocado growers (cluster)					
Region	Zone	Number of avocado trees bearing fruits			
		Mean	Sta. Dev	Minimum	Maximum
Oromia	East Shewa	120	232	1	900
Amhara	North Gojjam	188	188	10	800
Central Ethiopia	Silte Zone	32	29	3	85
Average		113	150	5	595
Mixed Type avocado growers					
Sidama	Central Sidama	86	233	5	1400
	N. Sidama	17	12	1	56
South Ethiopia	Wolaita	14	12	1	50
Average		39	87	2	502

Source: Computed from Survey Data, 2024

3.2.4. Average age and height of avocado trees

In Ethiopia, the introduction of avocado fruits has a longstanding presence in regions such as Wolaita and Sidama Zones, whereas it is a more recent development in areas like Silte and North Gojjam Zones. A significant proportion of avocado growers, specifically 74%, have trees that are aged between 5 and 10 years across various locations. Among the regions surveyed, 28.8% of avocado producers in the Wolaita Zone have trees exceeding 15 years of age, with Kaffa following at 21.4%. Conversely, in commercial avocado-growing regions like Silte, North Gojjam, and East Shewa, most growers tend to have trees that are younger (Figure 3.2.1).

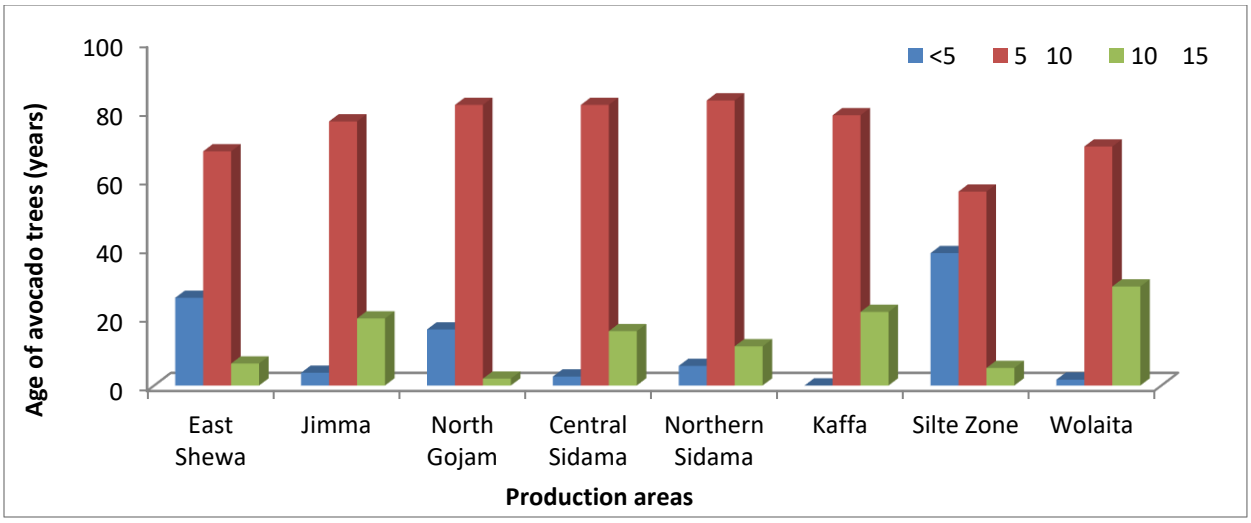

Figure 3.2. 1: Percentage of avocado trees with different age categories in different zones

The height of avocado trees varies significantly depending on the specific variety and geographical location. Commercial varieties typically exhibit a more uniform height and other fruit characteristics that are distinctive to their varietal traits. In contrast, most local avocado trees tend to be quite tall, displaying a range of canopy shapes and fruit characteristics (Figure 3.2.2).

Figure 3.2. 2: Height of sample local avocado trees (Gedeo, South Ethiopia Region)

In the study areas, 42.7% of avocado seedlings (un-grafted) from the Jimma Zone and 38.1% from the Kaffa Zone attained heights exceeding 8 meters, reaching a height of 15m. This elevated stature of avocado trees complicates the processes of fruit harvesting and canopy management. Several farmers have indicated that a substantial number of fruits remain unharvested as a result.

In contrast, no grafted avocado trees from East Shewa, North Gojjam, and Silte Zones reached heights greater than 8 meters. The commercial variants, such as Hass and Ettinger, have lower to medium heights. After 14 years of transplantation at Melkassa, the Hass variety reached 3.46 meters, while the Ettinger type reached 4.02 meters.

3.2.5. Avocado fruit yield per tree per year

Avocado fruit yield exhibits significant variability, which can be attributed to several factors, including the diversity of local trees, the range of commercial varieties, the age of the trees and plantations, and the management strategies implemented in the orchards and plantations.

In the Silte zone, where all avocado trees are grafted, the commercial varieties yield an estimated 194 kg of fruit per tree annually. Similarly, in East Shewa, the commercial avocado variety also consisting of grafted trees produces an estimated yield of 109 kg per tree per year (refer to Table 3.2.4). The survey indicates that an average of 151.5 kg of avocado fruit can be harvested from a single Hass variety tree. With a spacing of 5 m by 6 m, it is projected that more than 40 tons of actual yield could be obtained annually from Hass variety trees planted on one hectare of land. By implementing optimal agronomic practices, there is a significant likelihood of achieving an actual fresh yield exceeding 40t per hectare each year.

In regions where the majority of avocado trees are local varieties, the estimated average fruit yield is approximately 204 kg per tree annually, as observed in the Kaffa and Jimma zones (Table 3.2.4). Avocado varieties in the high rainfall areas such as Jimma, Kaffa, and South West Ethiopia are dominated by the local segregating materials.

The study also revealed that avocado producers (both commercial and local types) in the Central Sidama Zone attained the highest yield, with an average of 217 kg per tree (Table 3.2.4). In general, mixed avocado types yielded more than 145 kg per tree.

Table 3.2. 4: Estimated yield of avocado fruits per tree per year (kg/ tree)

Region	Zone	Mean	Std. Dev	Minimum	Maximum
Commercial (Cluster) avocado growers					
Oromia	East Shewa	109.0	77	3	300
Amhara	North Gojjam	151.5	9	2	50
C Ethiopia	Silte Zone	194.0	113	4	400
Mean		151.5	-	2	400
Local avocado growers					
Oromia	Jimma	207	126	50	800
SW Ethiopia	Kaffa	201	65	100	400
Mean		204	-	50	800
Mixed Avocado Growers					
Sidama	C. Sidama	217,0	326	10	2000
	N. Sidama	159.0	70	50	300
	Average	145.0	118	24	667
S Ethiopia	Wolaita	175.0	132	40	700
Mean		160.0	-	10	2000

Source: Computed from Survey Data, 2024

3.2.6. Agronomic and cultural management practices

The postharvest quality of avocados is established during their growth and maturation stages and is preserved rather than improved by the conditions encountered after harvest (Bill et al., 2014). Various pre-harvest factors, if inadequately managed, can detrimentally affect the quality of the fruit. A thorough understanding of these factors and their management strategies is crucial for minimizing postharvest losses in avocados. Table 3.2.5 provides a summary of the pre-harvest factors that have a direct influence on the postharvest quality of the fruit.

Table 3.2. 5: Key pre-harvest factors that affect the postharvest quality of avocado fruits

Pre-harvest factor	Postharvest effect on fruit quality	Recommended Management
Climate: temperature, wind, and rainfall	Increased disease incidence; Fruits chilling injury	Pruning to expose the fruit to direct sunlight
Rootstock or scion	Susceptibility to physiological disorders during the cold chain; postharvest decay	Choose less susceptible rootstock or scion
Pruning practices	Changes in fruit composition, influences the ripening behavior and decay(anthracnose),	Maintain a clean orchard and correct application of chemicals is important
Plant nutrition (N/Ca)	Development of physiological disorders (mesocarp discoloration or grey pulp) and rots	Manage vegetative growth and avoid excessive nitrogen during fruit development
Plant growth regulators	Poor storability	Manage vegetative growth
Irrigation	Influences polyphenol oxidase levels thus mesocarp discoloration	Avoid water stress during fruit growth and development

Source: Arpia et al., (2004) and Bill et al., (2014)

3.2.6.1 Irrigation and irrigation intervals in avocado production

The use of irrigation water for avocado production is relatively uncommon in regions such as Jimma, Kaffa, Wolaita, Sidama, and other areas of Ethiopia that experience high levels of rainfall, and local avocado varieties are predominantly grown. However, in East Shewa (Oromia), Silte Zone (Central Ethiopia), and North Gojjam (Amhara Region) where the production of commercial avocado varieties such as Hass and Ettinger has recently begun, furrow irrigation is used. According to the study, every avocado producer in North Gojjam employs irrigation, and 94.9% of growers in Silte Zone also make use of irrigation water (Figure 3.2.3).

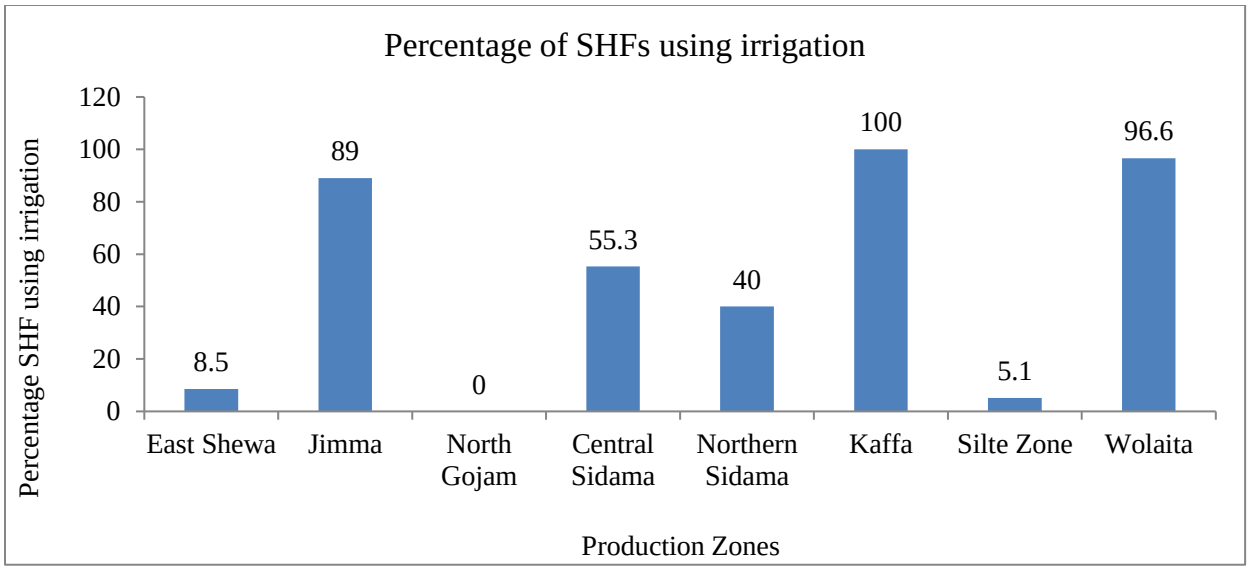

Figure 3.2. 3: Percentage of households using irrigation for avocado

Nearly 50% of avocado producers in the Sidama and Oromia areas utilize irrigation water for their avocado farming. While 95% of avocado growers in East Shewa depend on irrigation, those in Jimma and western Oromia do not use any irrigation. Additionally, avocado farmers in the Wolaita region do not use irrigation water for either local or commercial avocado varieties (Figure 3.2.4).

Figure 3.2. 4: Moisture-stressed Hass avocado tree (Wolaita area)

Since avocado trees have no dormancy (resting) period (Whiley et al., 1988; Whiley et al., 1994), they flower immediately after harvest and carry florets and fruits until the next harvest, making irrigation water necessary. If not irrigated flower and fruit fall can happen leading to very low yield. Disruption in irrigation can also cause high postharvest loss (undersized, shriveled fruits, leading to rejection) during the dry seasons; thus, avocado trees require supplementary irrigation.

Irrigation practices among farmers vary significantly in terms of intervals. For instance, avocado farmers in the Wolaita Zone utilize an irrigation schedule with intervals of 4.5 days, in contrast to the 20.6-day intervals employed by avocado producers in the Silte Zone (Figure 3.2.5). The results demonstrate a range of irrigation practices across different regions. Thus, it is imperative to determine the suitable irrigation intervals for avocado cultivation in each location, considering seasonal factors, the age of the trees, and the bearing potential of the varieties and plots, to improve productivity and decrease postharvest losses.

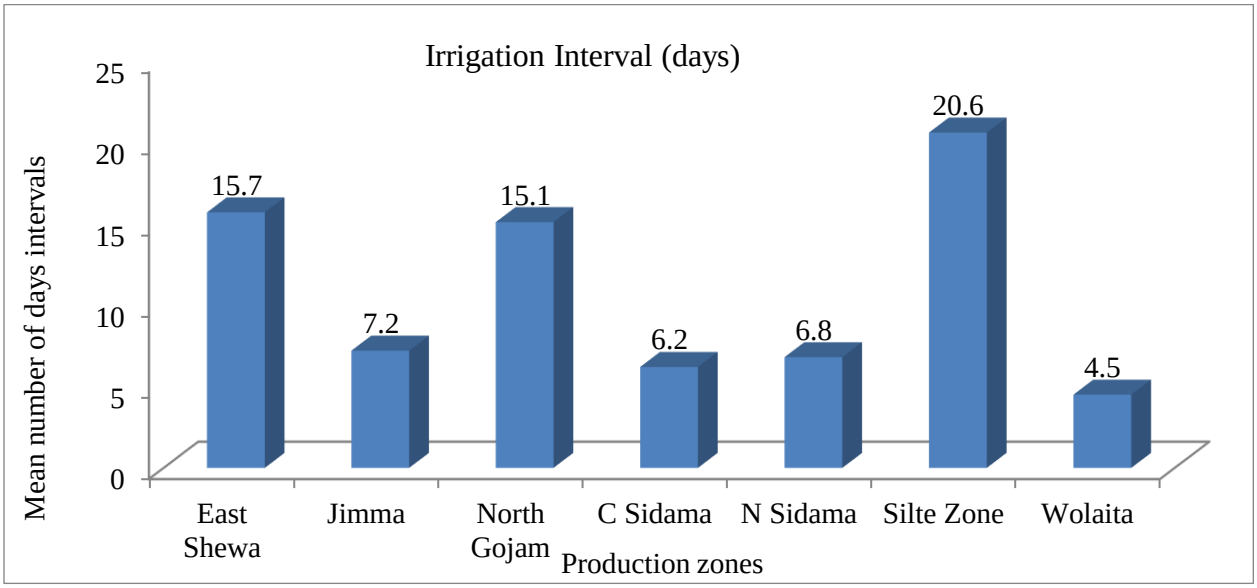

Figure 3.2. 5: Irrigation intervals used by sample smallholder avocado growers

3.2.6.2. Use of fertilizer and plant nutrients

Avocado trees, like all crops, depend on vital nutrients to ensure sustained yields. Poor management practices in avocado production can result in significant fluctuations in yield, with the production levels of one year failing to be mirrored in the following years. There is a high yield decrease of avocado trees under poor management.

Avocado growers are aware that both organic and inorganic fertilizers are vital for the proper growth and development of avocado plants; for example, 95.7% of avocado growers in East Shewa reported that they apply fertilizers to their avocado trees (Table 3.2.6).

Six percent of avocado producers reported that they utilize DAP fertilizer, while 6.6% reported the use of Urea fertilizer (Figure 3.2.6). Additionally, more than 60% of farmers indicated that they apply compost and animal manure in the growing of avocados. Thus, optimization of mineral nutrients, compost, and manure in avocado production is required in the future.

If avocado trees are not well managed with the required nutrients, the yield can decrease up to 70% when the soil is not properly fertilized, and the symptoms of nutrient deficiency vary according to the specific mineral (Dorantes et al., (2004). Fertilization should be done according to the age, size, and specific needs of every tree.

Table 3.2. 6: Proportion of producers who use fertilizer for avocado production

Region	Zone	Application of fertilizer (Y/N)	
		No	Yes
Oromia	East Shewa	4.3	95.7
	Jimma	6.1	93.9
	Average	5.2	94.8
Amhara	North Gojjam	0.0	100.0
Sidama	Central Sidama	0.0	100.0
	Northern Sidama	0.0	100.0
	Average	0.0	100.0
SW Ethiopia	Kaffa	35.7	64.3
Central Ethiopia	Silte Zone	7.7	92.3
South Ethiopia	Wolaita	10.2	89.8
Average		7.9	92.1

Source: Computed from Survey Data, 2024

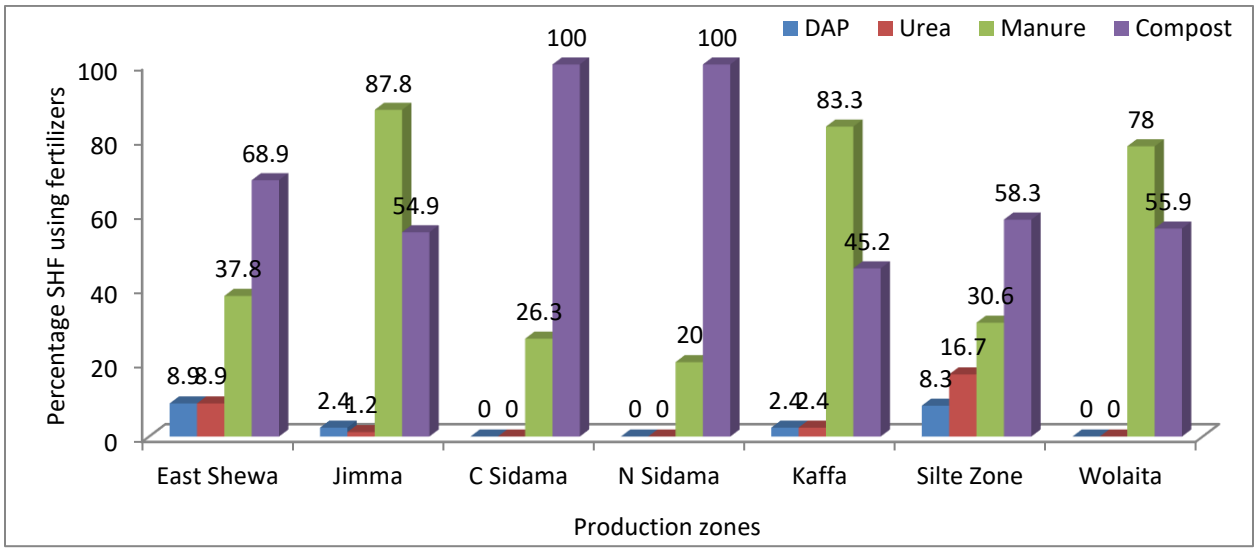

Figure 3.2. 6: Type of fertilizer used Vs proportion of avocado producers

The survey results indicate that 60.1% of avocado producers across the surveyed regions reported using manure as a fertilizer for their avocado plants, whereas 66.7% of growers from all areas acknowledged the use of compost (Figure 3.2.6.).

3.2.6.3. Pre-harvest avocado diseases

According to the survey results, 44.8% of avocado producers in the surveyed areas indicated the presence of serious challenges associated with pre-harvest diseases of avocados (Figure 3.2.7). The key avocado diseases in Ethiopia are Avocado Root Rot (*Phytophthora cinnamomi* R.), Avocado Fruits Anthracnose, Avocado Algal Leaf Spot/ALS/ and Avocado Powdery Mildew (Edeo et al., 2024), (Figure 3.2.7).

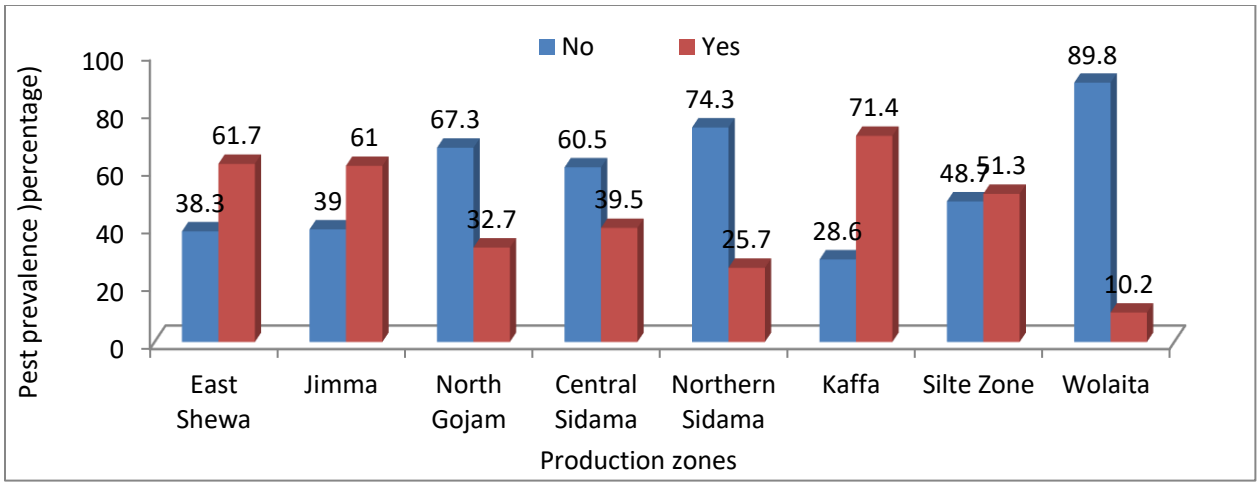

Figure 3.2. 7: Percentage of households facing with avocado pre-harvest diseases

3.2.6.4. Pre-harvest avocado insect pests

Although avocado producers are not fully aware of the precise pre-harvest pests impacting their trees and fruits, around 88% of them stated that they do not face any insect pest problems with avocado fruits. Conversely, nearly 12% acknowledged the presence of various pre-harvest insect pest issues related to avocados.

A range of insect pests has been documented as detrimental to avocado trees in Ethiopia, causing stress to the trees, producing undersized fruits, and resulting in decreased marketable yield and fruit quality. Two of the key insect pests attacking avocado fruits reported in Ethiopia are Fruits fly, and Persea mite. At present, there are no studied pest management control options for any specific pest in Ethiopia.

Figure 3.2. 8: Avocado Persea mite (East Shewa)

3.2.7. Avocado training, extension and advisory services

A large number of farmers planted Hass and Ettinger avocado varieties in all sample areas. Unfortunately, many of the grafted seedlings perished due to poor management practices after transplanting such as lack of protection from wild animal attacks, and a lack of irrigation during the dry season.

Among the surveyed farmers, over 90% of the Hass and Ettinger seedlings planted in previous years did not survive due to a variety of factors, including weak and inferior seedlings, damage

from animals, moisture stress during prolonged dry periods, and a lack of proper care from the growers. The surviving Hass and Ettinger varieties yield significantly less compared to avocado trees grown from seeds.

On average, 48.6% of participants in the study areas indicated that they had received training related to avocados, specifically in nursery propagation and field management. The data indicates that a significant 85.7% of avocado producers in North Gojjam have undergone training, in contrast to a mere 13.7% of producers in the Kaffa zone (Table 3.2.7).

Farmers producing local avocado varieties do not have access to training in post-harvest management, which is provided to those cultivating commercial varieties who receive guidance on effective harvesting and transportation methods. The primary responsibility for delivering such training rests with government bodies, including the Ministry of Agriculture, the Bureau of Agriculture, and the Agricultural Training Institute, along with support from non-governmental organizations and exporters.

Table 3.2. 7: Training received by sample smallholder avocado growers

Region	Zone	Training received on avocado production (%)	
		Yes	No
Oromia	East Shewa	63.8	36.2
	Jimma	30.5	69.5
	Average	47.2	52.8
Amhara	North Gojjam	85.7	14.3
Sidama	Central Sidama	55.3	44.7
	Northern Sidama	60.0	40.0
	Average	57.6	42.4
S. West Ethiopia	Kaffa	14.3	85.7
Central Ethiopia	Silte Zone	38.5	61.5
South Ethiopia	Wolaita	50.8	49.2
Average		48.6	51.4

Source: Computed from Survey Data, 2024

The extension services supporting the commercial varieties such as Hass and Ettinger avocado varieties are notably weak, which negatively impacts their survival rates in all surveyed areas. The avocado seedlings were often planted too close to water sources or in areas where the water table is high, leading to inadequate drainage during the rainy season. Additionally, a lack of proper agricultural inputs has resulted in nearly all farmers reporting low yields from their Hass and Ettinger trees, which range from 50 to 80 kg per tree each year, while local avocado trees can produce yields as high as 1000 Kg per tree. Most local avocado trees, which produce smaller fruits, yield twice a year, while commercial varieties typically yield once a year. Consequently, many farmers prefer to utilize local seed materials over Hass and Ettinger varieties. However, the yield from the local trees is characterized by erratic patterns, leading to fluctuations where certain years may experience low yields, and in some instances, there may be a complete absence of yield.

Farmers across all sample areas reported that extension agents do not encourage them to apply synthetic fertilizers. Consequently, the Hass and Ettinger trees appear weak and aged, characterized by sparse foliage and limited young shoots. This situation has prompted smallholder farmers in the Jimma, Kaffa, and Wolaita regions to prefer planting seedling avocado trees over grafted Hass and Ettinger varieties. Thus, there is an urgent need for effective avocado extension services that include comprehensive management packages for these commercial varieties.

In the Kaffa and Jimma Zones, the majority of farmers grow local varieties of avocados by sourcing seeds from local markets, juice houses, and the trees of fellow farmers. Some individuals opt to collect seeds from specifically chosen, high-yielding trees. The availability of grafted avocado trees is notably scarce, primarily sourced from the Bureau of Agriculture (BoA) or non-governmental organizations (NGOs). Consequently, only a limited number of farmers receive a small quantity of seedlings. Furthermore, the survival rate of grafted avocado seedlings distributed over the years has been alarmingly low, and access to Hass and Ettinger varieties remains challenging in various regions.

3.2.8. Avocado production constraints

The avocado subsector promises high potential in Ethiopia, but it is characterized by low yields and low income for producers. The results from Table 3.2.8 indicated that even though avocados can contribute to their livelihoods they are confronted by several constraints including, lack of irrigation facilities, low productivity, poor post-harvest, lack of extension services, limited knowledge, pest and diseases, lack of true type seedlings /poor seedlings quality and high price, etc... Avocado farmers in Ethiopia have low access to improved grafted varieties due to high costs and limited experienced nursery operators. Limited post-harvest technology, lack of processing plant, limited private investment in the avocado value chain, lack of avocado producer platform. Faris (2016) who shows that avocado has a significant economic and social role in livelihood and well-being has supported this, but its production is confronted by several constraints including degeneration of fruits, disease problems, and the absence of good agronomic practices.

Table 3.2. 8: Major avocado constraints in the sample areas during the study period

Major constraints for avocado production	Frequency	Percent	Rank
Land shortage	160	59.7	6
Lack of irrigation facilities	218	81.3	1
Low productivity	215	80.2	2
Lack of true type seedlings /poor seedlings quality and high price	179	66.8	5
Lack of scion sources	146	54.5	7
Lack of extension services and limited knowledge on avocado management	207	77.2	3
Disease and insect pest constraints	192	71.6	4
Flower/ fruits drop constraints	146	54.5	7
Poor postharvest management	207	77.2	3

3.2.9 Determinants of avocado yield

According to the correlation analysis result, the annual income of households from avocado fruits was strongly and positively correlated with the yield of avocado fruits and the number of fruit-bearing avocado trees. On the other hand, it has a negative correlation with the volume of total postharvest losses. Avocado postharvest losses were found positively correlated with the age of respondents, volume of DAP application, and length of avocado maturity. In contrast, Postharvest loss was found negatively and significantly correlated with annual avocado income and volume of compost application with a 1% significant level. Furthermore, the yield of avocado fruits was found to be positively correlated with income, number of avocado trees, and number of avocado trees bearing fruits, and volume of compost application, at a 1% significant level, Table 3.2.9.

Table 3.2. 9: Binary correlation analysis between pairs of different variables

	Age of respondents	Annual Avocado Income	Number of Avocado trees	Avocado trees bearing fruits	Volume of DAP Applied	Volume of Compost Applied	Total PHL	Total Yield _	Length of avocado maturity
Age of respondents	1	-0.044	0.033	0.067	.205**	-0.038	.145**	-0.034	.196**
Annual Avocado Income production (Birr)	-0.044	1	.536**	.621**	.121*	.321**	-.148**	.707**	0.06
Total number of Avocado trees	0.033	.536**	1	.879**	.416**	.244**	0.039	.654**	.111*
Number of avocado trees bearing fruits	0.067	.621**	.879**	1	.455**	.359**	0.004	.734**	.148**
Volume of DAP Applied	.205**	.121*	.416**	.455**	1	-0.07	.330**	0.004	.384**
Volume of Compost Applied	-0.038	.321**	.244**	.359**	-0.07	1	-.402**	.239**	-.298**
Total PHL	.145**	-.148**	0.039	0.004	.330**	-.402**	1	-0.06	.323**
Total Yield	-0.034	.707**	.654**	.734**	0.004	.239**	-0.06	1	0.048
Length of avocado maturity	.196**	0.06	.111*	.148**	.384**	-.298**	.323**	0.048	1
Maximum waiting hour to market	-.121*	.190**	0.066	0.078	0.059	0.103	-0.098	0.04	-0.098

***. Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*

Multiple linear regressions have the assumption of linearity, normality, absence of multicollinearity, and homoscedasticity. For the linearity assumption, the outcome variable should have a linear relationship with the independent variables. On the other hand, the residuals (errors), which are approximately normally distributed, are covered by the normality assumption. Homoscedasticity is related to the variance of the residuals that should remain constant across all levels of the independent variables. In other words, the spread of errors should be the same for

all predicted values. And, multicollinearity deals with the independent variables that should not be too highly correlated with one another.

The dependent variables we used for this analysis (Avocado yield and avocado postharvest loss) did not fulfill the above assumptions. Both of these variables violate at least two of the major assumptions. They have a positively skewed data distribution and non-linear relationship with many of the dependent variables, and thus quartile regression is used for this analysis, which does not require the above assumption to show the effect of the predictor variables on the outcome variable.

According to the regression analysis result, Training received in avocado production agronomic practices has a positive relationship with avocado yield with a coefficient of 446.941, and it is found significant at a 5% significance level. This positive coefficient suggests that receiving training in agronomic practices is associated with a substantial increase in avocado yield. Specifically, for avocado growers who received training, the avocado yield is expected to increase by approximately 446.9 units compared to those who did not receive training, holding other variables constant. Likewise, the Age of avocado trees has a positive impact on the yield of avocado fruits, according to the analysis result. The avocado trees with the age of 5 to 10 years are significantly different from that of the age less than five years at a 10% significant level. More specifically, the avocado trees with the age of 5 to 10 years are associated with an increase in avocado yield by approximately 356.324 units compared to the trees with a baseline category of < 5 years of age, holding other factors constant. Moreover, those who have applied compost on their avocado tree plantations have significant yield increments compared to those who did not apply. The avocado farmers who applied compost had five times more yield of avocados than those who didn't apply. On the other hand, chemical fertilizer application and a variety of differences had a negative relationship with the yield of avocados at 1% and 10% significant levels, Table 3.2.10.

Table 3.2. 10: Determinants of avocado yield with a 25-percentile quantile regression

Parameter	Coefficient	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
(Intercept)	1003.004	825.3815	1.215	0.226	-625.979	2631.987
Age of respondents	7.743	8.3957	0.922	0.358	-8.827	24.313
Sex of the respondent	325.855	257.2416	1.267	0.207	-181.840	833.550
Level of education	87.963	80.1308	1.098	0.274	-70.185	246.110
Years of experience	-4.757	129.4813	-0.037	0.971	-260.303	250.789
Training received	446.941**	225.5055	1.982	0.049	1.881	892.002
Age of Avocado trees	356.324*	197.1120	1.808	0.072	-32.698	745.347
Variety difference	-107.398*	62.0351	-1.731	0.085	-229.831	15.036
Insect pests	-86.875	100.9680	-0.860	0.391	-286.147	112.396
Grafted avocado trees	27.186	338.2485	0.080	0.936	-640.385	694.758
Irrigation use	284.230	228.0590	1.246	0.214	-165.870	734.331
Fertilizer application	-1129.759***	347.8177	-3.248	0.001	-1816.216	-443.301
Compost Application	5.041**	2.2659	2.225	0.027	0.569	9.513
Avocado disease	273.236	199.7926	1.368	0.173	-121.077	667.549
Length of maturity	-216.552	169.5641	-1.277	0.203	-551.206	118.102

*** Significant at 5% significant level*
** Significant at 10% significant level*

3.2.10. Determinants of avocado postharvest loss

According to the quantile regression analysis result, some variables such as local type of avocado verities, avocado pest infestation, length of avocado maturity period, the avocados harvested by wives, and the avocados harvesting in contact with the ground have a positive relationship with the dependent variable (Avocado postharvest loss amount), with 1% significant level. While grafted avocado trees have an inverse relationship with that of the dependent variable with a 5% significant level. The details of the relationship and impact of the independent variables on the dependent variable are summarized below.

Local avocado variety: the positive coefficient of 0.939 suggests that using the local variety of avocado is associated with an increase in postharvest loss compared to other varieties. For avocados harvested from local varieties, the postharvest loss is expected to be 0.939 units higher than the fruit harvested from other varieties like Hass and Ettinger varieties, assuming other factors remain constant. This result was found significant at 1% significant level, which suggests that the local variety is more susceptible to postharvest losses, potentially due to factors such as

lower resilience or shorter shelf life due to the current handling practices of the actors across the supply value chain.

Avocado Pest Infestation: A coefficient of 1.060 indicates that avocado pest infestations contribute positively to postharvest loss. The occurrence of pest infestation increases the postharvest loss by 1.060 units compared to non-occurrences, keeping other factors constant. This significant association implies that pest infestations are a critical factor in increasing postharvest loss, likely due to direct damage to the fruit and a decrease in its quality and quantity in the subsequent supply chain stages.

Length of Maturity Period: The positive coefficient of 2.533 shows that a longer maturity period is associated with higher postharvest losses. For each of the two months of prolonged maturity (6-7 months, to 8-9 months, or 10-11 months), increase the postharvest loss by 2.533 units, keeping other things constant. This result was found significant at the 1% significant level, which suggests that longer maturation time may lead to a higher vulnerability to postharvest loss, possibly due to factors like delayed harvesting or fruit over-ripening.

Harvesting fruits by wives: Avocado fruit postharvest loss is positively correlated with this independent variable. According to estimates, the postharvest loss is 3.673 times greater when the wife harvests the avocados than when the husband or kids do the handling. Due to the height of the trees and the inability to climb them, techniques like employing shaking trees, biting with sticks, or other improper avocado fruit harvesting methods may be the cause of this substantial association at the 1% level.

Time of harvesting: the positive coefficient of 2.865 indicates that not harvesting fruits during the right time of the day is associated with an increase in postharvest losses. This suggests that timing in the harvesting process impacts the fruit's quality, potentially due to factors like temperature, humidity, and handling conditions at different times of the day. Since it's significant at the 5% level, this is a fairly strong indicator that a more systematic approach to harvesting time could help reduce postharvest losses.

Fruits contact with the ground: Avocados harvested and come in contact with the ground are expected to have 4.630 times higher avocado postharvest loss than fruit that avoids ground contact. This large coefficient, highly significant at the 1% level, underscores the damaging impact of ground contact on fruit quality, likely due to bruising, contamination, or accelerated spoilage.

Grafted avocado trees: The negative coefficient of -2.593 suggests that avocados from grafted trees are associated with a reduction in postharvest loss compared to non-grafted trees. Harvesting from grafted avocado trees is associated with a decrease in postharvest loss by 2.593 times more than the non-grafted avocado trees, holding other factors constant. This 5% significant level implies that grafted trees may produce more resilient fruit with better postharvest durability, potentially due to improved genetic traits such as resistance to pests, and diseases, or better fruit quality (see Table 3.2.11).

Table 3.2. 11: Determinants of avocado postharvest loss with a 25-percentile quantile regression

Parameter	Coefficient	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
(Intercept)	1.166	2.9343	0.398	0.691	-4.607	6.940
Age of respondents	-0.004	0.0300	-0.138	0.890	-0.063	0.055
Level of education*	-0.458	0.2759	-1.661	0.098	-1.001	0.085
Sex of the respondent	1.202	0.9192	1.308	0.192	-0.606	3.011
Years of experience*	-0.793	0.4412	-1.798	0.073	-1.662	0.075
Training received	0.181	0.7315	0.247	0.805	-1.259	1.620
Variety local	0.939 ***	0.2085	4.504	0.000	0.529	1.349
Avocado pest infestations	1.060***	0.3311	3.200	0.002	0.408	1.711
Grafted trees	-2.593**	1.0911	-2.377	0.018	-4.740	-0.446
Length of maturity	2.533***	0.5747	4.406	0.000	1.402	3.663
A person involved in harvesting						
Husband	-1.030	0.8041	-1.280	0.201	-2.612	0.552
Wife	3.673***	0.8941	4.108	0.000	1.914	5.433
Children	-1.229	0.7710	-1.594	0.112	-2.746	0.288
Hired labor	1.168	0.7552	1.547	0.123	-0.318	2.654
Time of harvesting						
Morning	0.116	1.0823	0.107	0.915	-2.013	2.246
Evening	1.323	0.9024	1.466	0.144	-0.452	3.099
Noon	0.034	0.8951	0.038	0.969	-1.727	1.795
Any time of the day	2.865**	1.4039	2.040	0.042	0.102	5.627
Method of harvesting						
Using harvesting bag	0.703	1.1731	0.599	0.549	-1.605	3.011
Dropping Fruits	0.563	1.1152	0.505	0.614	-1.631	2.757
Using harvesting poles	1.405	0.8850	1.587	0.113	-0.337	3.146
Shaking trees	2.918	2.8992	1.006	0.315	-2.787	8.622
Hitting fruits with sticks	0.682	1.0537	0.647	0.518	-1.392	2.755
Length of the stalk in cm	0.081	0.3455	0.235	0.814	-0.599	0.761
Harvesting fruit in contact with the ground	4.630***	0.7693	6.019	0.000	3.117	6.144

*** *Significant at 1% level of significance*
** *Significant effect at 5% level of significance*
* *Significant effect at 10% level of significance*

3.3. Harvesting of Avocado Fruits

Harvesting and postharvest handling of fruits is a process or operation that includes different activities like harvesting, sorting produce, grading, packing, storing, transportation, loading, and unloading, done by the farmers themselves or traders or brokers (Hoffman *et al*., 2012).

3.3.1 Estimated length of time from flowering to harvest

Avocado flowering and harvesting dates vary depending on variety, agroecology, and management practices. According to Paull and Duarte (2011), the time required from bloom to fruit harvesting in avocado varies by race (type): Mexican type (6-9 months); West Indian (5-9 months); and Guatemalan (10-16 months). These avocado races (types) cross each other naturally in the producing countries particularly where seeds are used for planting materials. Currently, any local type of avocado tree in Ethiopia could have originated from any one race or a combination of several races. This makes determining specific harvest dates challenging.

The findings from the survey indicated that a significant number of participants (188) stated that avocado fruits require a maturation period of 8-9 months, while 178 growers reported a shorter timeframe of 6-7 months for the same process (Table 3.3.1). However, as avocado growers do not record tree growth event data, both by variety, by tree, or by location, the exact flowering, vegetative flushing, and harvesting period remains unknown and needs to be studied for each production area. Further scientific research should be conducted to identify the start and end of the flowering season, other phenological growth stages, and exact maturity dates of avocado fruit varieties in each major agroecology.

Table 3.3. 1: Estimated time from flowering to harvest in the study areas

Region	Zone	Estimated period from flowering to harvest (months) (%)			
		6-7 months	8-9 months	10-11 months	12 months
Oromia	East Shewa	43	4	0	0
	Jimma	19	53	8	2
	Average	31	29	4	1
Amhara	North Gojjam	28	34	15	0
Sidama	C. Sidama	24	14	0	0
	N. Sidama	25	10	0	0
	Average	25	12	0	0
SW Ethiopia	Kaffa	8	32	2	0
C Ethiopia	Silte Zone	38	1	0	0
S Ethiopia	Wolaita	21	38	0	0
Total		178	186	25	2

Source: Computed from Survey Data, 2024

3.3.2 Maturity indices and harvesting of avocado fruits

It is commercially important to identify the minimum maturity (i.e., the maturity standard) stage of avocados that assures an acceptable eating experience and minimal fruit disorders while allowing early harvest to take advantage of higher early season pricing (Hoffmann et al., 2012).

The maturity of avocado fruit differs depending on the variety. Since flowering occurs continuously, so does fruit maturity and harvesting. The date of avocado harvest is influenced by the minimum accepted maturity, market prices, and the required storage or transport time because of the effect of maturity on disorder susceptibility (Hoffman *et al*., 2012).

Maturity indices for harvesting avocados are important in order to prevent harvesting of immature or over-mature fruit and to reduce postharvest losses (Bill *et al*., 2014). Harvesting immature fruit can result in inadequate ripening, resulting in an inferior fruit quality. Avocado fruits are highly variable, and even those graded for similar size and appearance do not behave in the same manner after harvest. This is particularly problematic for those involved in the sale of the "ready-ripe" market. To determine the best harvest point, two quantitative maturity and harvest indices are used: oil and dry matter content. Other complementary indexes can be considered, such as the size of the fruit and the appearance of the seed skin.

In the study areas, 97.7% of avocado growers indicated that they determine the maturity stage by examining the color and texture of the avocado fruits, regardless of the variety. In contrast, 56.0% of these growers assess maturity based on the size of the fruits (Figure 3.3.1). It is important to note, however, that size is not a good indicator for local avocado varieties, as the fruit size can differ considerably among trees, making it impossible to find identical fruit characteristics between two distinct local avocado types.

Pearson (1975) reported that with increasing maturity the avocado oil content in the fruit increases while the water content or dry matter decreases. Landahl *et al.*, (2009) stated that the oil content in the mesocarp and its composition vary within the fruit. On the other hand, their oil content is also influenced by cultivar type, cultural practices, and environmental conditions. Generally, the oil content in the mesocarp is used as an indicator to harvest avocados.

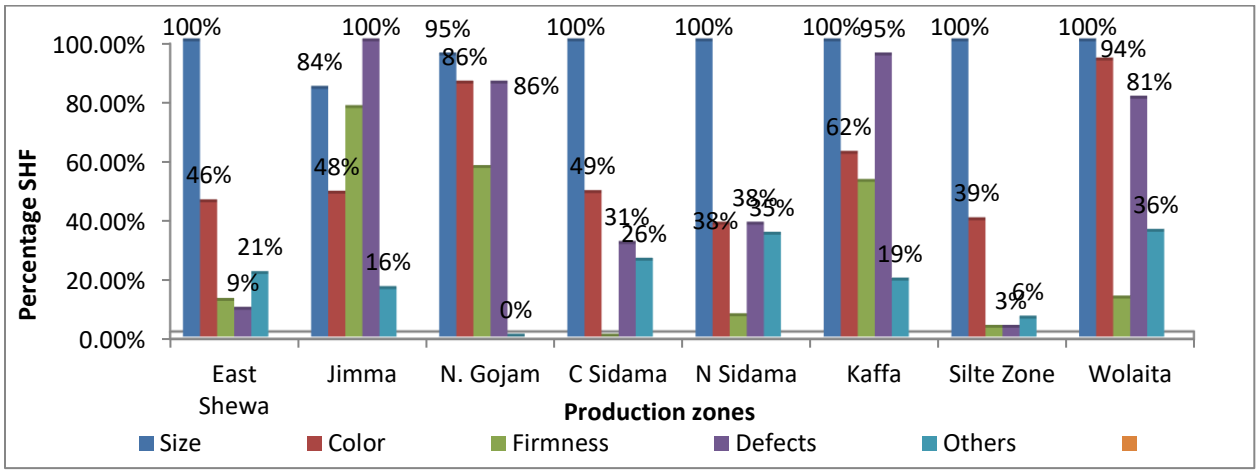

Figure 3.3. 1: Maturity indicators of avocado fruits in the sample smallholder producers

Some avocado producers in Jimma and Kaffa Zones choose to leave their matured fruits on the trees until market conditions yield a more favorable price. Consequently, when they eventually harvest later in the year, the trees start flowering and bear fruits so late. In this way there is a tendency that avocado supply is almost throughout the year. This strategy contributes to a nearly year-round availability of avocados.

Although commercial avocados in some exporting areas are harvested when the fruits are matured, local avocado trees are harvested irrespective of maturity. This practice can lead to the development of lesions in the field, including issues such as anthracnose, avocado blight, and minor mechanical damage. Consequently, Ethiopian consumers often find that the avocados available in the market are of inferior quality.

3.3.3. Harvesting practices of avocado fruits by growers

Avocado fruit should be harvested at the optimal stage. Harvesting avocado fruit at very early maturity can lead to poor fruit ripening and quality due to shriveling, rubbery texture, and when ripe, stringy vascular tissue, insipid flavor, and increased fruit rot (Lee *et al.*, 1983). On the other hand, harvesting the fruit after the optimal time may shorten its post-harvest life. The majority of avocado trees in the Jimma, Kaffa, Wolaita Zones, and Sidama Region are originated from seeds, which have uneven fruit characteristics, grow very tall as high as 15 meters height, and are difficult to harvest.

Because avocado trees and branches are tall and easily broken, improper postharvest handling practices, inadequate transportation, and unfavorable storage conditions all contribute to the development of avocado fruit postharvest diseases (Hoffmann *et al*., 2012).

When children climb trees to harvest avocados, they use long sticks with curved ends. This practice results in the fruits being dropped from a height of up to 15 meters onto the ground, which causes fruits to crack, split, and other invisible bruises and damage on the surfaces of fruits and causes substantial injury and bruises for the entry of pathogens, including anthracnose caused by *C. gloeosporioides* of avocado fruit. This problem is common in orchards located in the study areas and is worsened by outdated harvesting and postharvest handling techniques, inadequate transportation systems, and poor storage conditions at wholesalers and retailer establishments. As a result, this contributes to the spoilage and loss of avocado fruits.

3.3.4. Harvesting period of commercial avocado varieties

As discussed above, the avocado harvesting season in Ethiopia varies from region to region depending on climate, altitude of the area, and variety of avocados under consideration. Avocados flower continuously for at least a month, which leads to a month-long harvest. However, leaving fruits on the tree after maturity prevents the next flowering; it appears that avocados do not flower until all of the fruits have been collected from the tree, thus late harvesting disrupts the tree's phenology.

There is one harvesting season for all commercial avocado varieties in most production areas from July to September. Hunda'ol Primary Avocado Producers Cooperative Association (East Shewa) made harvesting of avocado Hass variety, for export for the first round in the last week of September (Meskerem 18/ 2016 EC), and the last harvest in February from leftover fruits. Avocados flower continuously for at least a month, which leads to a month-long harvest.

However, leaving fruits on the tree after maturity prevents the tree from flowering. It appears that avocados do not flower until all of the fruits have been collected off the tree, and late harvesting disrupts the tree's phenology.

3.3.5. Harvesting period of local avocado types

According to avocado grower's response, almost all small fruit-sized local avocados (Mexican dominant) are harvested twice a year in Wolaita, Sidama, and all other high-rainfall areas of Ethiopia; the main first harvesting season is February and March, whereas the second harvesting season overlaps with those commercial varieties and starts from July end in August from local trees. But the harvest is only once a year from large fruits sized mixed local avocado types in southwest Ethiopia such as Jimma, Buno Bedele, Illuababora, Kaffa, Bench Shako, and other areas where the area receives high rainfall with longer rainy periods.

On the other hand, where there is rainfall throughout the year, such as in Tullo and Cheta Woredas in the Kaffa Zone, there is a propensity that if harvesting delays, the corresponding flowering and harvesting will be delayed and avocado harvesting will become throughout the year. Depending on the farmer's harvesting seasons, a year-round avocado harvest is possible, with early harvest causing trees to flower earlier and set fruits and late harvest causing trees to flower and set fruits later. The main harvesting season of avocados in SW Ethiopia is during the rainy season. However, it is reported that rain just before harvest can increase fruit turgidity and susceptibility to mechanical damage (Hoffmann *et al*., 2012).

3.3.6. Harvesting frequency of avocado fruits

As previously stated, local avocado trees are harvested twice a year, while commercial types are harvested once a year (Figure 3.3.2). The majority of growers in Jimma (42.9%) and North Gojjam (41.5%) reported to harvest avocados only once a year. Small harvests occur before and after the main season. In the majority of studied areas, there is an indication of harvesting avocados more than once a year.

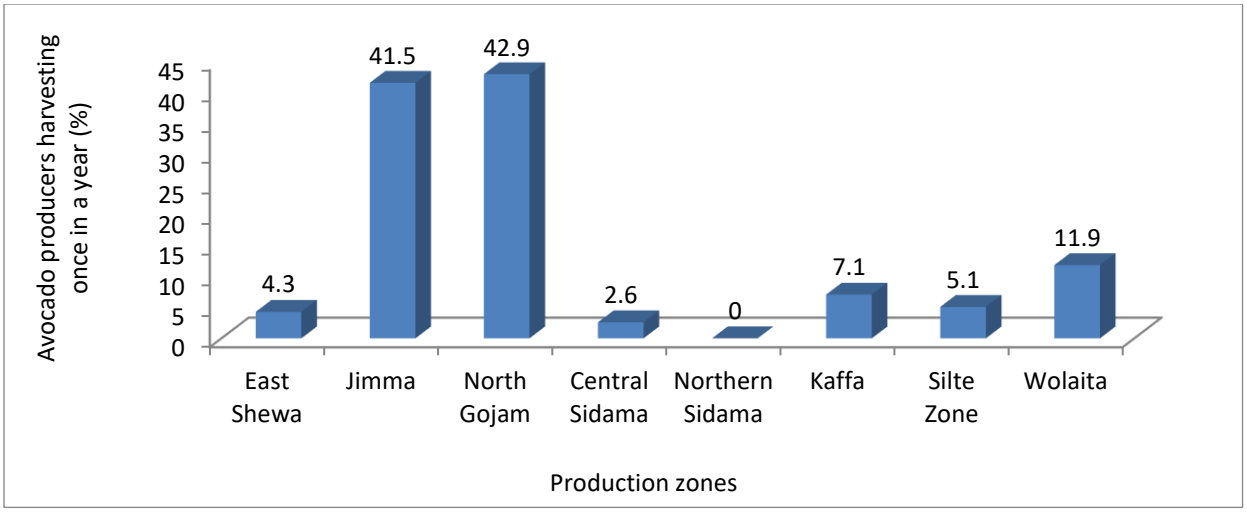

Figure 3.3. 2: Percentage of households harvesting avocado fruit only once in a year

3.3.7. The role of household members in avocado harvesting

In the process of avocado harvesting, all household members participate; however, children are the most prolific pickers, contributing to 68.3% of the total harvest. This is followed by husbands at 61.6% and wives at 41.7% (Figure 3.3.3).

It is important to note that avocado trees possess soft stems, which may be prone to breaking under the weight of a substantial fruit yield or when harvesters ascend taller trees. Regardless of the harvester, avocado fruit must be collected without incurring mechanical damage, including cuts, scratches, or abrasions. Such damage can detrimentally impact the fruit's cosmetic appearance and provide an entry point for postharvest pathogens that can cause decay during storage and transportation (Bill *et al.,* 2014). Furthermore, bruising can lead to localized softening.

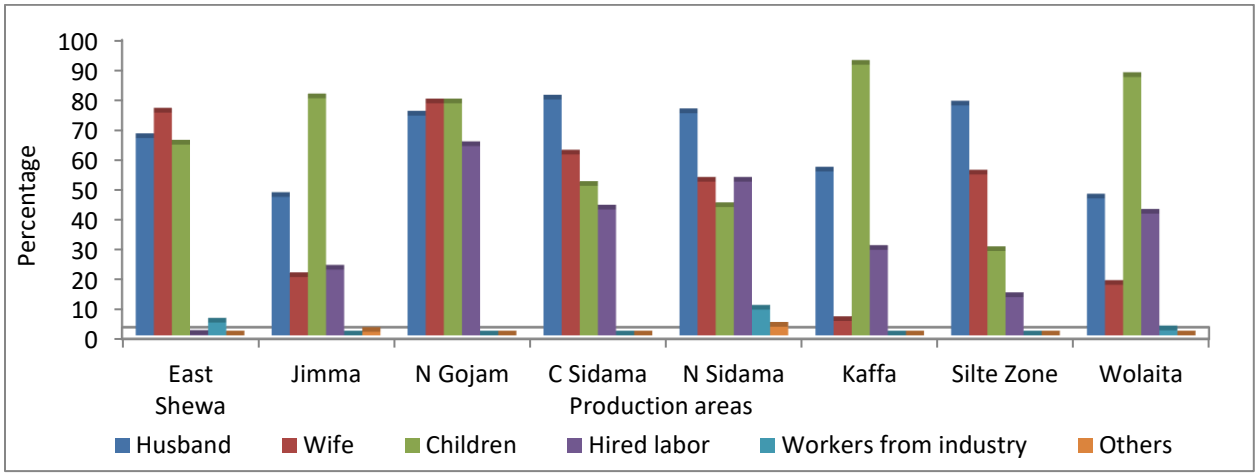

Figure 3.3. 3: Household members involved in avocado fruit harvesting

3.3.8. Time of day avocados are harvested

The time of day to harvest avocado fruits should be carefully considered. Temperatures above 30°C between harvest and the start of cooling can increase rots and flesh disorders (Arpaia *et al*., 1992), and fruit can ripen more quickly and have less disease when ripe if harvested at field temperatures above 30°C (Considine *et al*., 2005). It is well established that avocado fruit cannot be harvested during wet weather conditions because the presence of water droplets on the fruit surface can favor the incidence of postharvest diseases during distribution and storage (Darvas, 1982). 'Fuerte' and 'Hass' varieties harvested during wet conditions exhibited significant lenticels damage in comparison to fruit picked in dry weather. However, lenticels damage does not affect 'Hass' fruit quality because the fruit turns dark purple in color during ripening and the lenticels damage cannot be seen clearly in purple background.

Generally, the occurrence of lenticels damage is higher for all the fruit picked early in the season (Darvas, 1982) and incidences of vascular browning were also reported to be higher in fruit harvested when they are wet. For example, the incidences of vascular browning increased significantly in 'Hass' picked during wet conditions and late in the season when compared to the fruit picked during dry weather conditions or early in the season (Werman and Neeman, 1987; Duvenhage, 1993). Furthermore, fruit picked late was reported to ripen much faster, particularly when grown in warmer areas (Vuthapanich *et al*, 1995).

In the study areas, avocado fruits are harvested in the evening, at noon, or at any time of day, with 87.5% of respondents harvesting in the morning followed by 27.5% at midday (Table 3.3.2). Most farmers are aware that harvesting in the morning with dew and harvesting with heat during the midday have a negative impact on the shelf life and transportation of avocado fruits. To avoid fruit damage, the fruit is often placed in either a soft picking bag attached to a harvesting pole or directly into a plastic crate. The fruit must be relocated to the shade immediately after harvesting to reduce weight loss caused by moisture loss, which occurs rapidly when exposed to the sun.

Table 3.3 2: Harvesting time of avocado fruits by smallholder growers

Region	Zone	Harvesting time (%)			
		Morning	Evening	Noon	Any time
Oromia	East Shewa	91.5	48.9	29.8	2.1
	Jimma	97.6	2.4	19.5	2.4
	Average	94.5	25.7	24.6	2.3
Amhara	North Gojjam	100.0	57.1	2.0	0.0
Sidama	Central Sidama	97.4	21.1	23.7	0.0
	N. Sidama	91.4	42.9	34.3	0.0
	Average	94.4	32.0	29.0	0.0
SW Ethiopia	Kaffa	54.8	16.7	9.5	57.1
C. Ethiopia	Silte Zone	92.3	35.9	25.6	2.6
South Ethiopia	Wolaita	71.2	0.0	71.2	5.1
Average		**87.5**	**24.8**	**27.6**	**7.9**

Source: Computed from Survey Data, 2024

3.3.9 Avocado harvesting method

In the study areas, avocados are harvested in different ways: by hand with a harvesting bag, hand-picking and dropping, harvesting poles, shaking trees to drop fruits, and using sticks. The majority of respondents (55.5%) in the study areas harvest their avocado fruits by hand-picking and dropping them, whereas 49.1% harvest their avocado fruits by hand picking and using a harvesting bag (Figure 3.3.4).

Hand picking is quite common for grafted short avocado trees that are carefully cared for. For export purposes, exporters require that harvesters wear hand gloves during harvesting and subsequent PH management practices, such as in the packhouse to avoid fruit contamination. This suggests that all framers should plant grafted commercial avocado varieties and minimize planting avocado trees from seeds in Ethiopia.

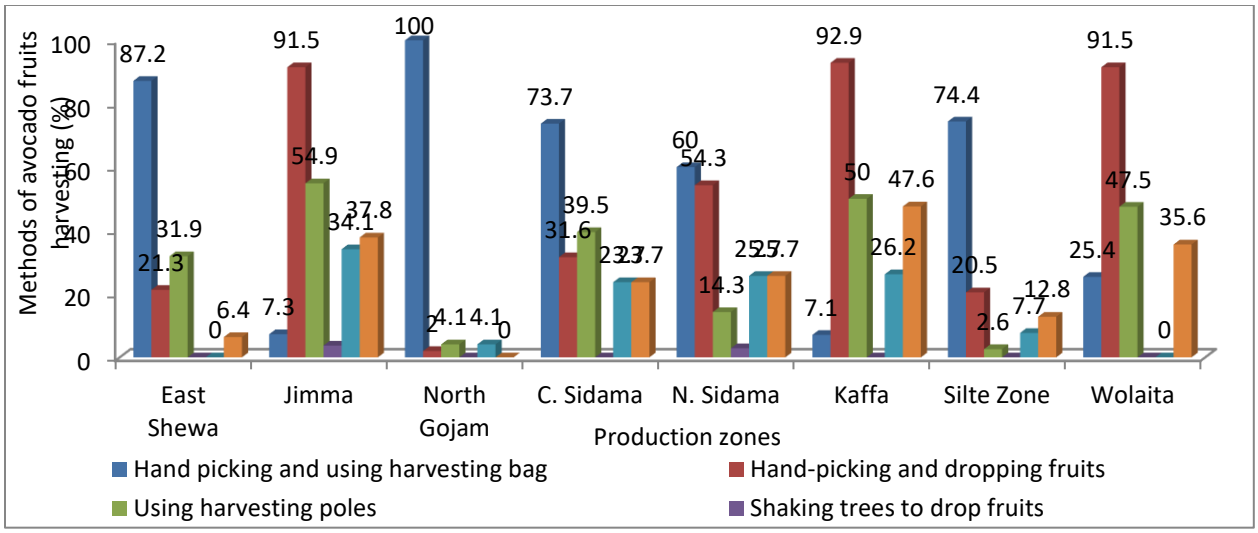

Figure 3.3. 4: Methods of harvesting avocado fruits under the sample smallholder producers

Avocado growers who harvest avocados by shaking avocado trees or branches produce an enormous quantity of physically damaged fruits, as well as a significant quantity of immature fruits that cannot be sold right away. Picking poles, which would have reduced post-harvest losses, are not widely used. Avocados are packaged in sacks, bags, and baskets after harvesting, which causes additional bruising and physical damage.

3.3.10. Tools and materials used for avocado harvesting

Avocados should never fall into the ground or be excessively exposed to the sun. The exposure of avocados to the sun increases the internal temperature of the fruit, which triggers physiological and chemical maturation processes that speed up maturation and decay. Avocado fruits can be harvested either by manual clipping or plucking which involves pulling the fruit from the tree, resulting in a stem scar where the stem is detached; this method is sometimes referred to as 'snap' picking (Hoffman et al., 2012). Historically, international markets favored fruit that was clipped with the stem intact, but there is a growing acceptance of plucked fruit. Avocado fruits can be clipped using secateurs or picking poles, with the option of utilizing standard or self-propelled mechanical ladders.

Smallholder farmers in Ethiopia, particularly in regions with high rainfall where local tall avocado trees are common, commonly use long picking sticks, often made from bamboo, equipped with hooks at the end to harvest avocados. While these sticks enable them to reach fruits located high in the trees, determining the ripeness of each avocado from a distance remains a challenging task.

In the study areas, avocado fruits are harvested using a variety of tools and materials, including plastic crates, wooden crates, harvesting poles, polypropylene bags, secateurs, and ladders. Some 87.2% of the respondents utilize polypropylene bags for harvesting avocado fruits, followed by harvesting poles with 22.5% of the respondents, and 15.3% of the respondents use plastic crates (Figure 3.3.5).

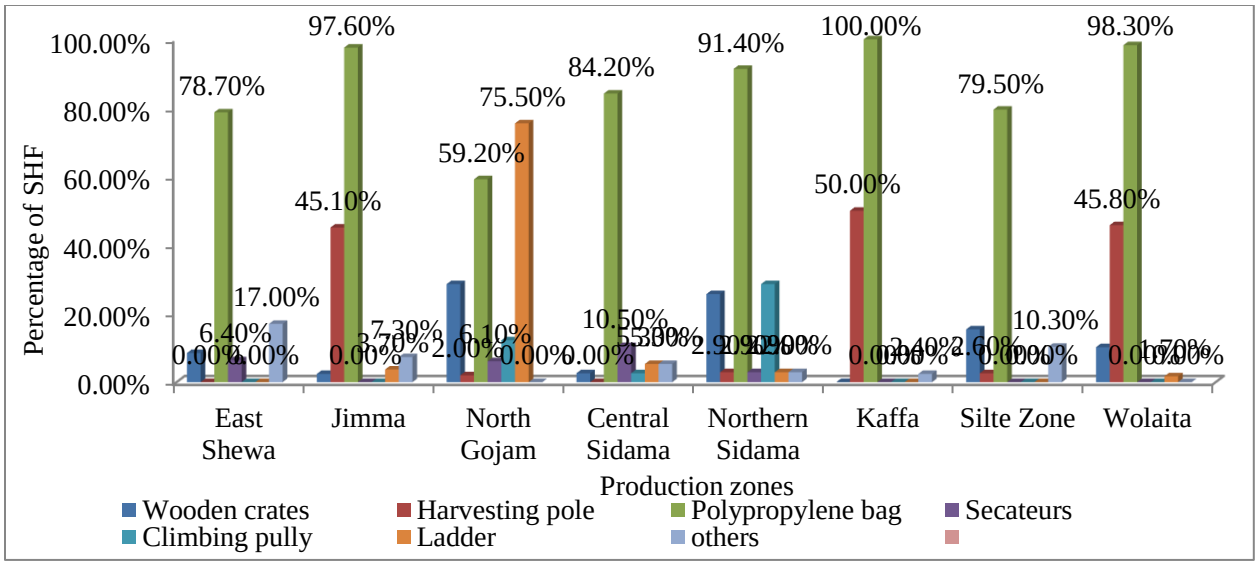

Figure 3.3. 5: Tools used for harvesting avocado fruits by growers

Fruit that is difficult to reach from the ground is picked by hand from towering trees using picking poles or ladders. Picking poles must have a clipper or knife attached to the end, with a catching or collection bag made of cloth (Bill *et al.*, 2014). The use of clippers is suitable for removing avocado fruit from trees. There is a local picking pole developed by Alemayehu *et al.*, (2024), that should be demonstrated in the major avocado production areas.

The peduncle of avocado fruits should be cut and not separated from the tree by pulling down the fruit (Dorantes *et al.*, 2004). The cut of the peduncle should leave a portion of 8 to 10 mm on the branch, in order to avoid a fast maturation of the fruit; when the peduncle is completely separated, the internal respiration of the fruit increases, helping the entry of pathogens.

Leaving very short fruit stalks on avocado fruits is important for various reasons. It is recommended that about 1 cm of the pedicel fruit stalk should be left attached to avocado fruits (Bill *et al.*, 2014). However, except for export purposes, where fruits are sorted, graded, and cleaned for all local markets, almost all avocado growers, collectors, and transporters are not aware of the importance of not removing fruit stalks starting during harvesting. One cannot get avocado fruits with fruit stalks in any local markets in Ethiopia. Avocado fruit ripening begins at the points of attachment to the detached fruit stalk while the other side of the fruit is still green or unripe; once the other side of the fruit is ripe, the side of the fruit stalk begins to rot, as seen in all Ethiopian fruit supermarkets. Almost all avocado fruits in the markets and along the roadsides of Adama, Mojo, and Bishoftu towns are contaminated with post-harvest diseases. Harvesting methods were shown to affect the postharvest fruit quality of 'Fuerte' for which pedicels must be manually clipped. On the other hand, 'Hass' can be snap-picked without causing an undesirable effect on their fruit quality (Köhne and Kremer-Köhne, 1995).

Except in the East Shewa, North Gojjam, and Silte Zones, where the majority of Hass varieties are exported, harvesters and farmers remove the fruit stalk before packing into the bags. When they keep the fruit stalks, the mean stem length is 0.77 cm (Figure 3.3.6), with commercial growing areas like North Gojjam leave up to 1.4cm. Unfortunately, some traders remove fruit

stalks that are accidentally left on avocado fruits since they take up space during the shipping of approximately 60000 kg of avocados in a van.

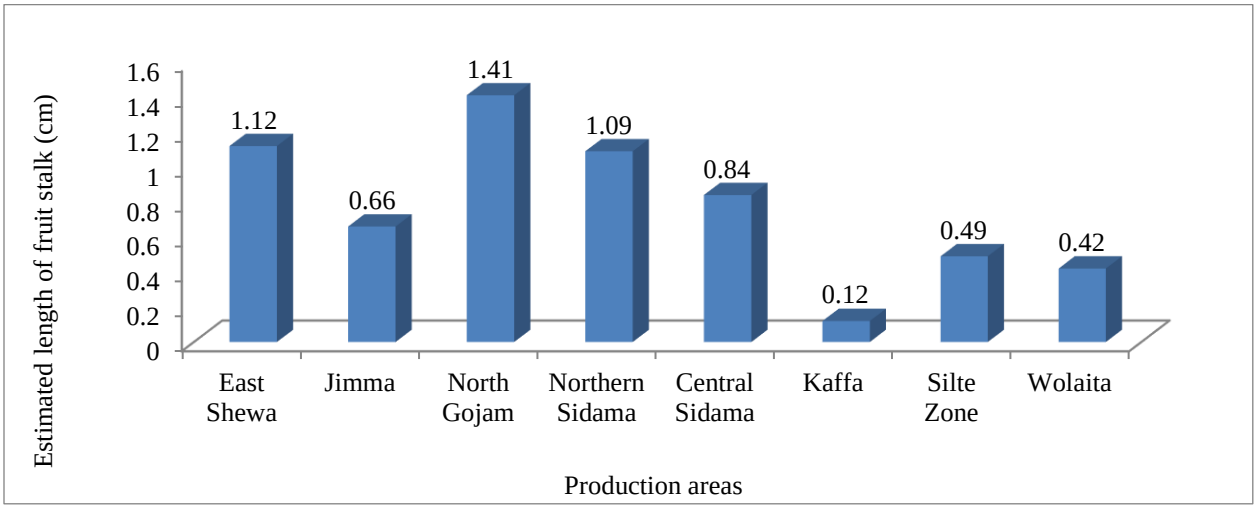

Figure 3.3. 6: Estimated fruit stalk (stem) left on the avocado fruits during harvesting

Overall, the peduncle of avocado fruits should be cut and not separated from the tree by pulling down the fruit (Dorantes *et al*., 2004). The cut of the peduncle should leave a portion of 8 to 10 mm on the branch, in order to avoid a fast maturation of the fruit; when the peduncle is completely separated, the internal respiration of the fruit increases, helping to the entry of pathogens.

3.3.11. Time required for completing avocado harvesting from a single tree

The time required to harvest avocados is determined by the number of avocado fruits per tree and the height of the tree. Harvesting from grafted commercial avocado trees takes less time than harvesting from local very tall avocado trees because the tree is shorter and easier to harvest, and the yield is also limited, allowing for harvesting in less than 30 minutes. Harvesting time in the study areas ranged from 22 to 58 minutes per tree, with Hass avocado varieties in East Shewa, North Gojjam, and Silte Zone taking an average of 22, 15, and 31 minutes per tree, respectively (Table 3.3.3).

Table 3.3 3: Estimated time required for completing harvest from a single avocado tree

Region	Zone	Time taken to complete harvesting from a single tree (minute)			
		Mean	Std. Dev	Minimum	Maximum
Oromia	East Shewa	22	13	0	60
	Jimma	53	59	5	360
	Average	38	36	3	210
Amhara	North Gojjam	15	8	0	35
Sidama	C. Sidama	49	27	1	120
	N. Sidama	44	25	5	120
	Average	47	26	3	120
SW Ethiopia	Kaffa	58	34	20	180
C. Ethiopia	Silte Zone	31	22	0	90
S. Ethiopia	Wolaita	56	78	1	600
Average		**43**	**47**	**0**	**600**

Source: Computed from Survey Data, 2024

3.4 Avocado Fruit Postharvest Management

3.4.1. Placement of avocado fruits after harvest

The harvested fruits should be collected in proper places, such as boxes or baskets, in order to avoid mechanical damage and further injuries. After harvesting, the avocado fruit must be carefully transferred from the picking bag into the field crates to avoid mechanical injuries, especially bruising. The fruit should not be placed on the ground to avoid any contact with the soil. This will help to prevent contamination by foodborne pathogens that can survive in the soil such as *Listeria monocytogenes* (Ultee *et al*., 1999). Exposure to the sun will tend to increase the pulp temperature, which accelerates ripening and shortens the shelf life of the fruit (Vuthapanich, 1995; FAO, 2005). The exposure of avocados to the sun triggers physiological and chemical maturation processes that speed up maturation and decay. The harvested fruit should be collected in proper places, such as boxes or baskets, to avoid mechanical damage and further injuries.

In the study areas, on average, 65.2% of avocado growers reported harvested avocado fruit contact with the ground. Even with the Hass variety, there is fruit contact with the ground; nearly 46.8% of Hass growers in East Shewa reported avocado fruit contact with the ground, and in North Gojjam, where the Hass variety is widely grown, nearly 80% reported avocado fruit contact with the ground during harvesting (Figure 3.4.1).

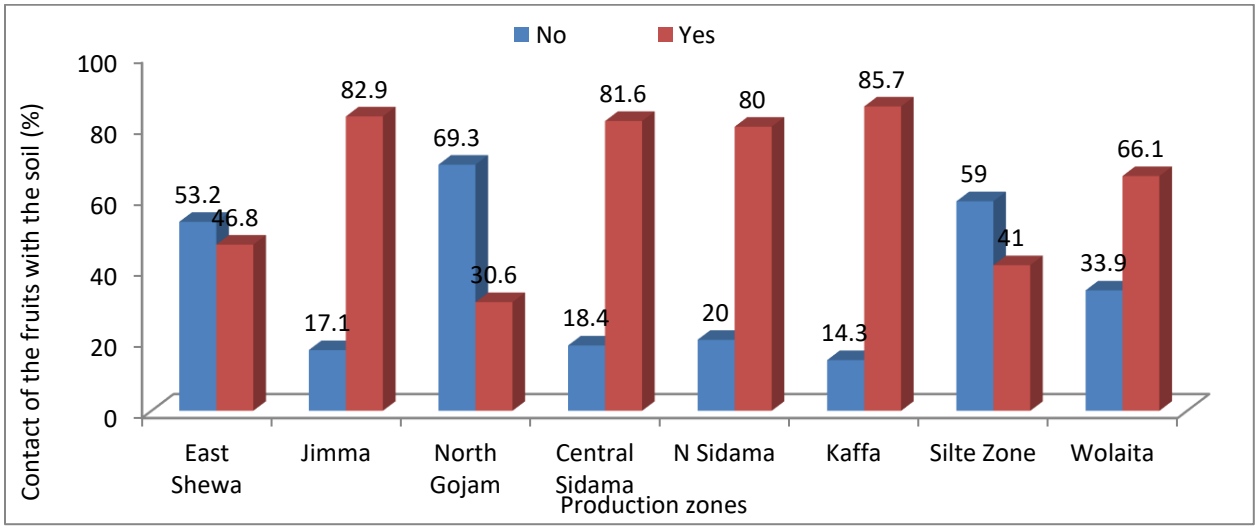

Figure 3.4. 1: Percentage of households harvesting avocado fruits in contact with the ground

Avocado fruits are stored in a cool place after harvesting before being transported to the packhouse for grading, sorting, cleaning, and packaging. According to the study, the majority of avocado growers, around 65.9%, store fresh avocado fruits in the shade of trees while 9.8% of avocado growers place their fresh fruits under basic shade structures such as Enset leaves (Table 3.4.1).

Table 3.4. 1: Placement of avocado fruits after harvest by the sample smallholder producers

Region	Zone	Placement of avocado fruits after harvest (%)			
		Under constructed shade	Under the shade of trees	In open space	Others
Oromia	East Shewa	31.9	25.5	2.1	44.7
	Jimma	1.2	96.3	1.2	4.9
	Average	16.6	60.9	1.7	24.8
Amhara	North Gojjam	6.3	100.0	0.0	0.0
Sidama	C. Sidama	36.8	65.8	2.6	28.9
	N. Sidama	42.9	57.1	2.9	37.1
	Average	39.8	61.5	2.7	33.0
SW Ethiopia	Kaffa	31.0	90.5	2.4	2.4
C Ethiopia	Silte Zone	43.6	17.9	2.6	35.9
S Ethiopia	Wolaita	23.7	47.5	0.0	49.2
Average		**23.6**	**65.9**	**1.5**	**23.8**

Source: Computed from Survey Data, 2024

3.4.2. Precooling of avocado fruits

A pre-cooling operation in avocado fruit is generally carried out after packaging (Dorantes et al., 2004). Pre-cooling is of prime importance for the shelf life of avocado, because it diminishes or slows the metabolic rate, ethylene synthesis and its action on the fruits, loss of texture, fungal infections, fruit ripening, and conditions the fruit for preservation at low temperatures. Ideally, there should not be more than six hours from harvest to pre-cooling, and when this is not possible, the harvested fruits should not be allowed to reach an internal temperature higher than 26°C in the field and during its transportation to the packinghouse.

According to the study, 93.9% of avocado growers do not precool their fresh fruit (Figure 3.4.2). There are no facilities for temperature management for fresh avocados; they simply harvest and sell them. Farmers in East Shewa provide their Hass fresh avocado fruits to the packhouse immediately. However, avocado fruits grown in various parts of the country are arriving in Addis Ababa's major marketplaces without temperature control. Of course, although the fruits are bulked in the truck, the transporters travel during the night during the cool time.

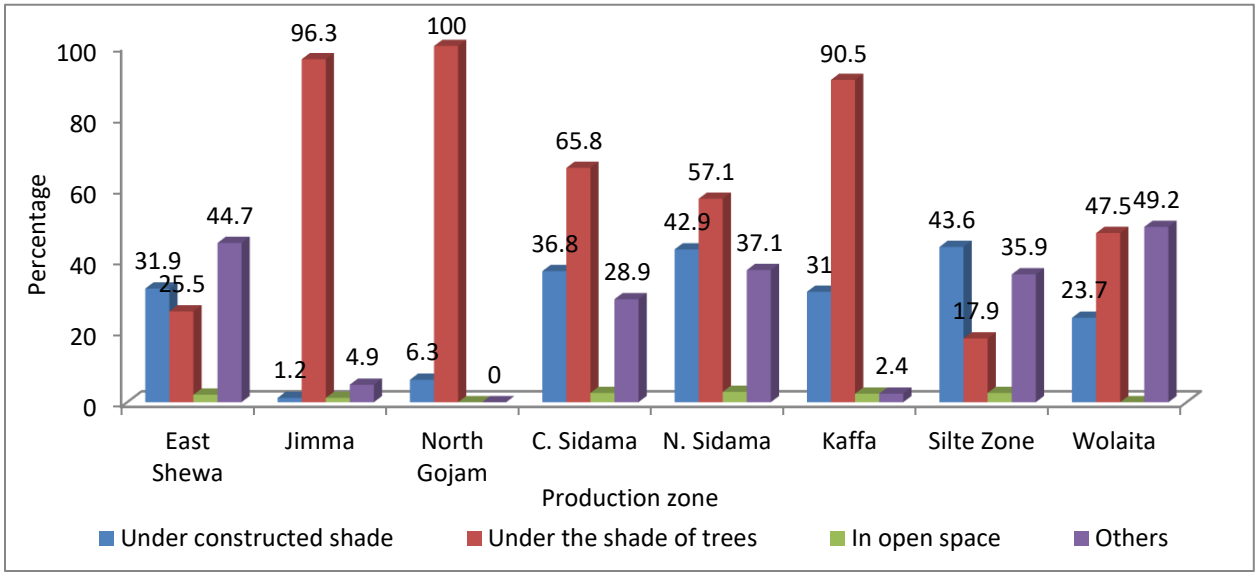

Figure 3.4. 2: Percentage of farmers practicing precooling of avocado fruits after harvest

It is highly recommended that avocado fruits be cooled as soon as possible after harvesting to delay ripening and related softening (Bill *et al.,* 2014). Pre-cooling is very important, especially when the field temperatures are high (>25 °C). On arrival, the fruit must be pre-cooled to about 16 °C to remove the field heat. Commercially, hydrocooling is the most common method used.

The quantity of the field heat is usually large, and cannot be eliminated fast enough in a regular refrigeration room (Dorantes *et al.,* 2004). The freeze-blast method is the best suited for avocado precooling. It is carried out until the temperature in the fruit reaches 6-7°C for "Fuerte" and "Hass". The time that is required to achieve these temperatures varies according to the initial temperature of the fruit, the temperature, and velocity of the air, and the final temperature of the fruit. However, it is important to end the pre-cooling process when the temperature of the fruit is 2°C above the ideal storage temperature. It is also of prime importance to ensure that the storage temperature will not be lower than that established for the fruit, otherwise chilling injury can occur. The pre-cooling process lasts from 8 to 12 hours, with a relative humidity of 90% to 95%.

3.4.3. Sorting and grading of avocado fruits

Sorting- avocado fruits should be properly sorted, and any damaged, split, cracked, or bruised fruits should be removed; otherwise, these damaged fruits ripen quickly in bulk and become a source of contamination for all other healthy fruits in bulk, stores, and retailers before reaching consumers. Fruit cuts, punctures, and bruises on avocados increase ethylene production and accelerate fruit softening and eventual rotting. In other words, to decide when to harvest an avocado, it is important to determine the minimum ripeness.

According to the survey data, 68% of avocado growers in all study areas sort their fresh avocado fruit before selling it in local markets, whereas 32% do not sort the fresh produce in the field (Figure 3.4.3). Thus, capacity building across the supply chain is required for the proper sorting of fruits at all supply chain stages.

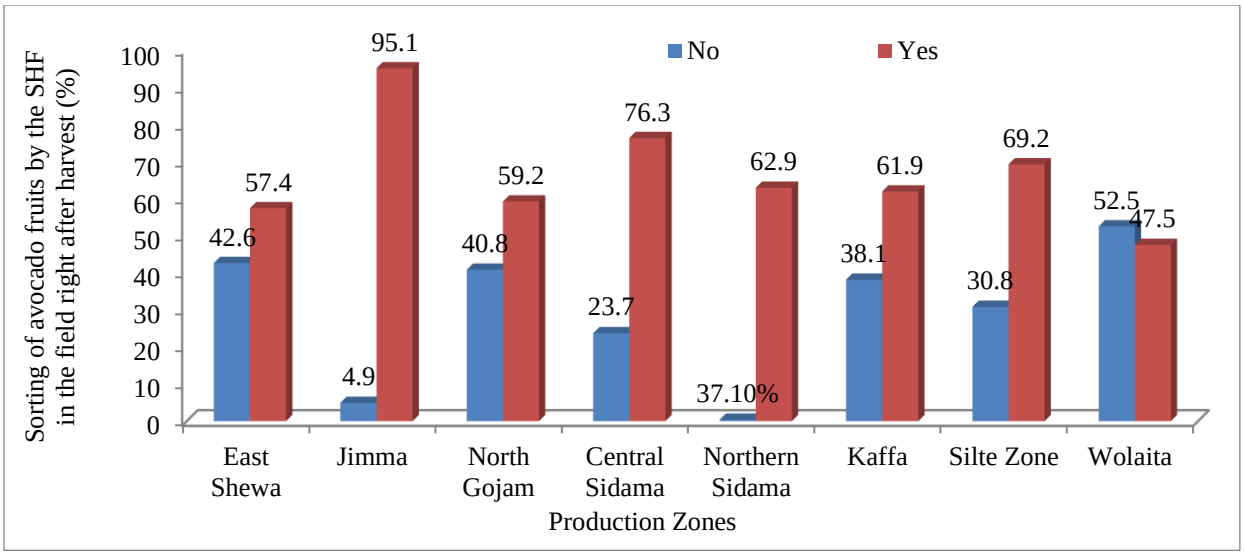

Figure 3.4. 3: Percentage of farmers practicing sorting of avocado fruits right after harvest

Avocado fruits are sorted based on fruit size and shape, and field defects such as sunburn, wind rub, and insect damage. Field defects detracting from external appearance can usually be removed during harvesting and sorting in the field, but defects that are not obvious at sorting and packing are more difficult to manage (Hofmann *et al.*, 2012). Mechanical damage during harvesting and packing may not be obvious during sorting until several days later. Flesh defects are often not visible externally, especially for black-skin cultivars such as 'Hass', but have a significant impact on the value and consumer satisfaction.

For export and supermarket purposes avocado fruit is sorted in the packhouse. Avocado fruit from the orchard is sorted and graded according to the following commonly used quality criteria for grading avocados (Bill *et al.*, 2014): size, skin color, and the absence of cuts or wounds, blemishes, insect damage, and spray residue. Moreover, after ripening, the fruit must be free from diseases (anthracnose and stem-end rot), physiological disorders (grey pulp, vascular browning), and bruising (White *et al.*, 2001).

Washing- avocado growers wash fruits that are consumed at home. However, 96.7% of avocado growers do not wash fresh avocado fruits, while only 3.3% of producers do so before selling them at the local market (Figure 3.4.4). They said that because they are not ordered by avocado collectors, buyers, or traders, they do not wash. Packhouse centers with facilities for sorting, grading, and cleaning avocado fruits are needed in main production areas.

Among the 3.3% of avocado growers that wash their fresh fruit, 61.5% use river water, while 30.8 use tap water (Figure 3.4.5). Avocado fruits are washed in the packhouse under certified hygienic conditions. Thus, a strong PH extension system should be established to prevent avocado fruits from becoming contaminated with foodborne pathogens and other agrochemicals.

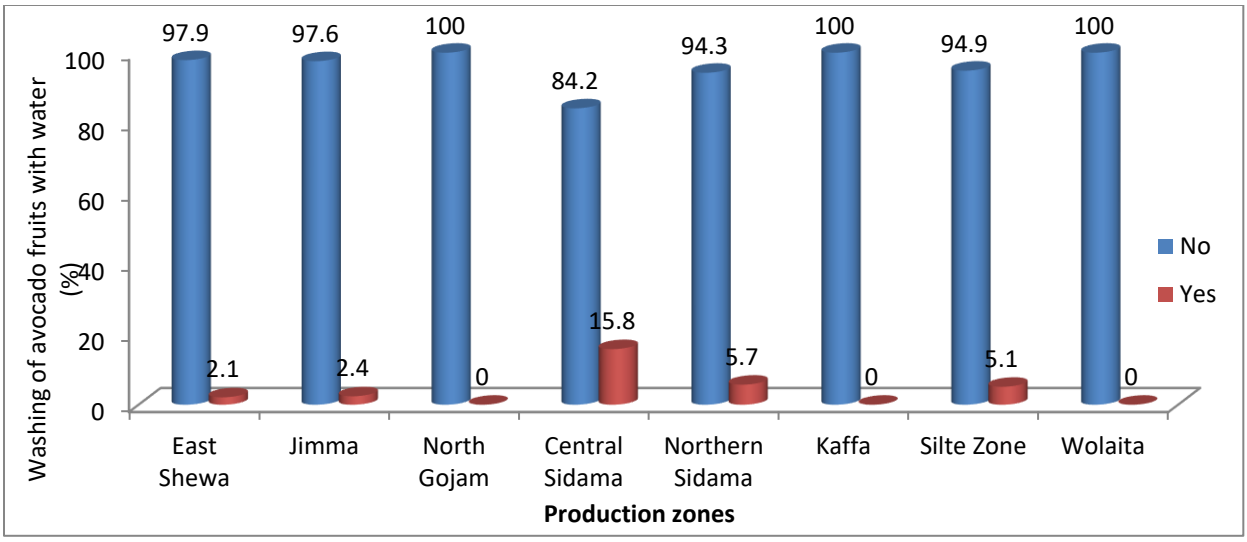

Figure 3.4. 4: Percentage of farmers practicing water wash of avocados

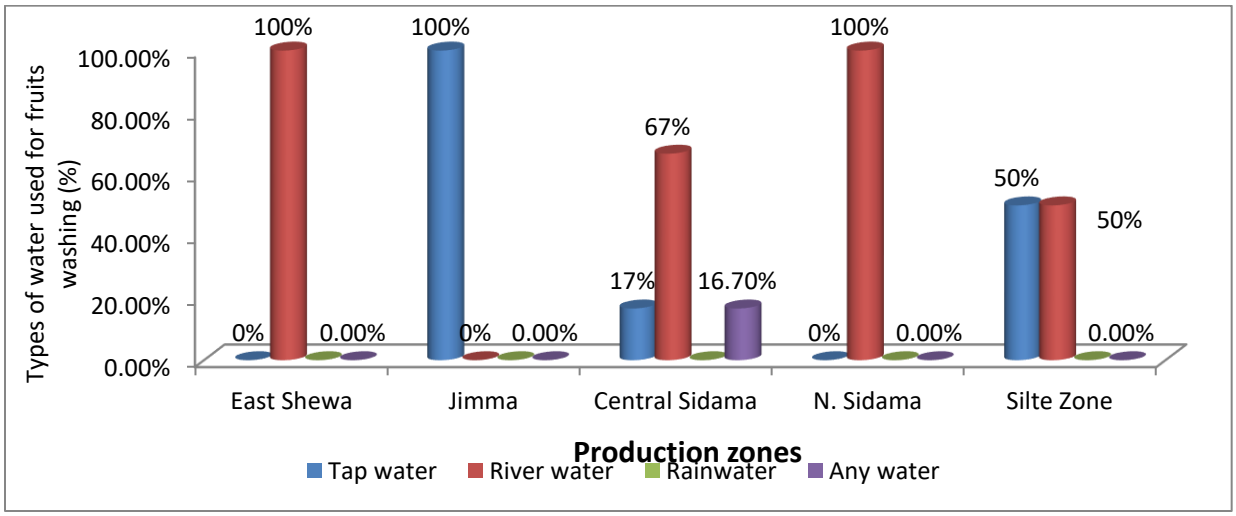

Figure 3.4. 5: Types of water used for washing

Grading - Grading avocado fruit differs from physical sorting. Avocado fruits are graded in most commercial packing facilities after they have been sorted for physical damage, undersize, and immaturity. To avoid confusion and misdiagnosis of causes and solutions, quality issues must be described clearly and unambiguously for growers, packers, and marketers (Hoffman *et al.*, 2012). According to the study results, 60.1% of respondents grade their fresh avocado produce, while 39.9% do not grade their avocado fruits (Figure 3.4.6).

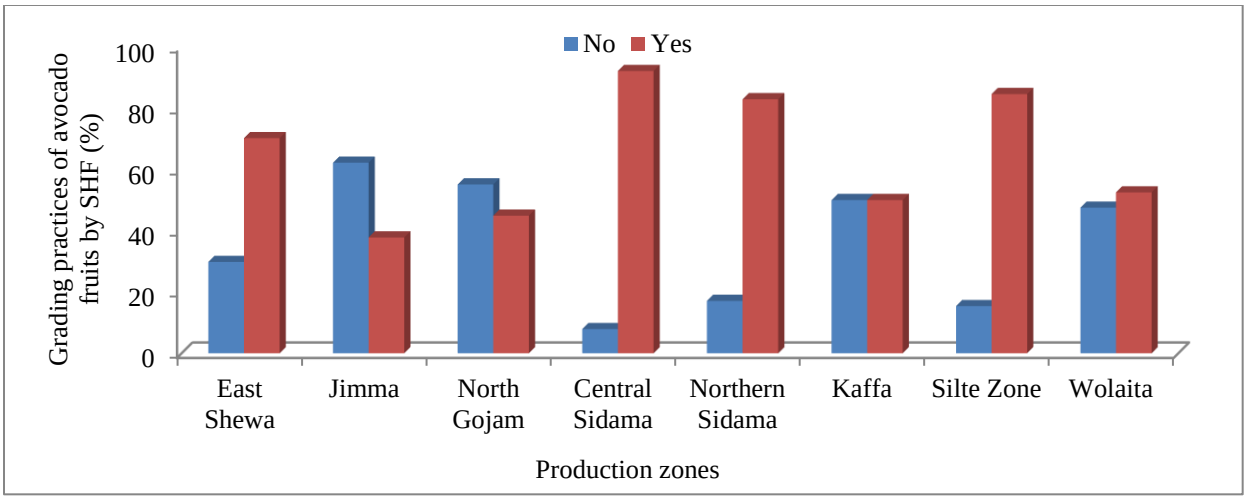

Figure 3.4. 6: Percentage of farmers who practice grading of avocado fruits after harvest

Avocado fruits in Southwestern Ethiopia are generally sold ungraded at local, zonal, and Addis Ababa markets and shipped to neighboring countries ungraded, while graded and packaged avocadoes are exported to the UAE, the UK, and the Netherlands. Avocado grader machines can classify avocados quickly and accurately, the avocado electronic weighing and classifying machine produced by First Industry has become very popular recently.

The avocado growers grade fresh avocado fruits mainly by maturity, size, color, firmness, defects, and others. The survey indicated that 97.4% of the respondents grade by fruit size; 56.8% by maturity; 56.0% by color; and 51.3% by external defects (Figure 3.4.7).

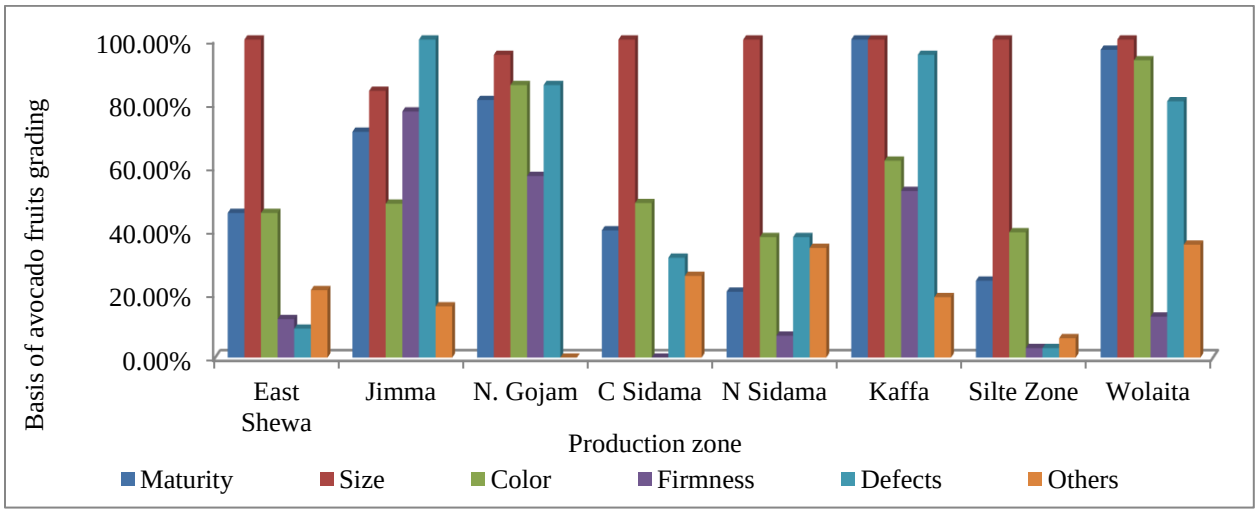

Figure 3.4. 7: Basis for avocado fruits grading by the smallholders

However, each of these criteria does not work where extreme diversity of avocado types exists (seedling trees) in the country. The majority of avocado populations, approximately greater than 95% of the trees are seedling trees whereas commercial variety might be less than 5%. Thus, no two seedling trees have exactly the same fruit characteristics for adopting grading by size, maturity and color (Figure 3.4.8).

Figure 3.4. 8: Avocado fruit diversity (size, color, shape, maturity) in local market

Farmers may sort their fruits, but they do not engage in grading, as there is currently no national standard for avocado grading. Consequently, graded avocados are unavailable in supermarkets or retail markets in Addis Ababa and other cities across Ethiopia. Ethiopia is currently exporting graded avocado fruit, which requires it the adoption of grading standards from the Codex Alimentarius Commission. Therefore, it cannot be assumed that avocado fruits categorized by size are necessarily considered graded.

Avocado grading in Ethiopia is carried out at the packhouse level, following the guidelines established by the United Nations in 2017. However, there is a lack of standardization in the grading process among various stakeholders, including producers, collectors, assemblers, transporters, wholesalers, retailers, and consumers. A significant number of avocado growers indicated during the interview that they categorize their fruits from one to three grades, as illustrated in Figure 3.4.9. Consequently, it is imperative to conduct a more comprehensive examination of the sorting and grading processes of avocados throughout the entire supply chain.

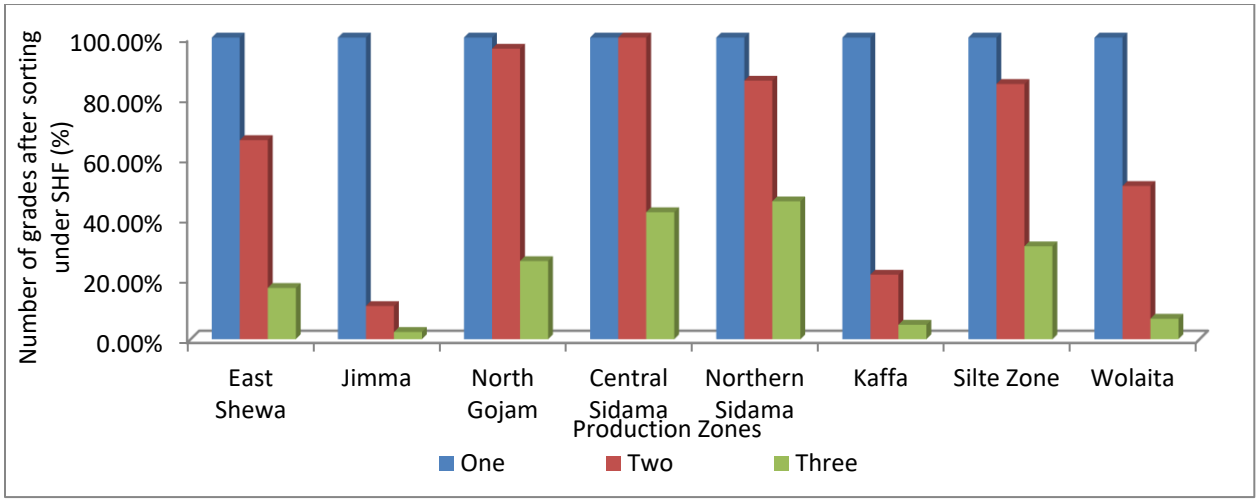

Figure 3.4. 9: Proportion of farmers practice different numbers of grades after sorting

Avocado producers categorize their fruits into three specific grades. Of these, 53% are classified as Grade I, while 17% fall under Grade II, and 2% are designated as Grade III (Table 3.4.2). Consequently, it is essential to verify this data regarding smallholder avocado grading in relation to the export status of avocado fruits in Ethiopia.

Table 3.4. 2: Proportion of avocado fruits in different grades in the survey areas

Region	Zone	Proportion of grades		
		Grade I	Grade II	Grade III
Oromia	East Shewa	70	24	2
	Jimma	47	3	0
	Average	58	13	1
Amhara	North Gojjam	52	12	1
Sidama	Central Sidama	67	28	5
	Northern Sidama	67	27	6
	Average	67	28	6
SW. Ethiopia	Kaffa	42	7	0
Central Ethiopia	Silte Zone	67	26	5
South Ethiopia	Wolaita	31	21	2
Mean		**53**	**17**	**2**

Source: Computed from Survey Data, 2024

3.4.4. Storage of avocado fruits

Avocado fruits for selling are not stored and immediately taken to the market; however, producers in the study areas cannot harvest and sell immediately. This leads to storing avocado fruits temporarily. On the other hand, the study indicated that producers harvest and the fruits are immediately taken to the packhouse for export without any delay. Most producers store one night until taking to the local market the next day early in the morning. This is particularly important for local avocado types, where the fruit skin is very thin and susceptible to damage along the supply chain stages (Table 3.4.3). On the other hand, fruits from Hass avocado variety have very thick skin that it can be stored for 4 days until taking to the local market without any damage, such as in East Shewa and Silte Zones. Similarly, local avocado types can ripen within 3- 5 days, whereas fruits from Hass variety would take many days for ripening.

Table 3.4. 3: Average storage days before marketing by the smallholders in different zones

Region	Zone	Average storing days before marketing		
		Export market	Local market	Home consumption
Oromia	East Shewa	0	4	8
	Jimma	-	1	3
	Average	-	3	5
Amhara	North Gojjam	1	1	2
Sidama	Central Sidama	-	0	5
	Northern Sidama	-	1	6
	Average	-	1	6
South West Ethiopia	Kaffa	-	1	4
Central Ethiopia	Silte Zone	-	4	6
South Ethiopia	Wolaita	-	1	5
Average		-	2	5

Source: Computed from Survey Data, 2024

Avocados require a cold chain to deliver optimal ripeness at the grocery stores. That means once they're picked, they need to be kept refrigerated until they arrive at the grocery store. Additionally, avocado supply chain managers must make sure temperatures are not too cold, or else the avocados will shrink. They must also limit the amount of exposure to sunlight, which could cause the avocados to over ripen and rot. From farm to fork, moving avocados requires careful attention to transportation and warehousing to keep customers happy and reduce waste.

Avocado growers in the study areas utilize various methods for storing their harvest, including the use of plastic crates, bulk storage on mud or cement paved floors, wooden crates, and elevated shelves. A significant proportion of sample respondents (46%) of avocado growers opt for bulk storage directly on mud floors, while 15.3% of growers store their avocados in wooden crates (Figure 3.4.10). The storage of avocado fruits necessitates the establishment of suitable facilities and infrastructure, alongside the development and demonstration of appropriate technologies that actively involve a significant number of avocado producers in Ethiopia.

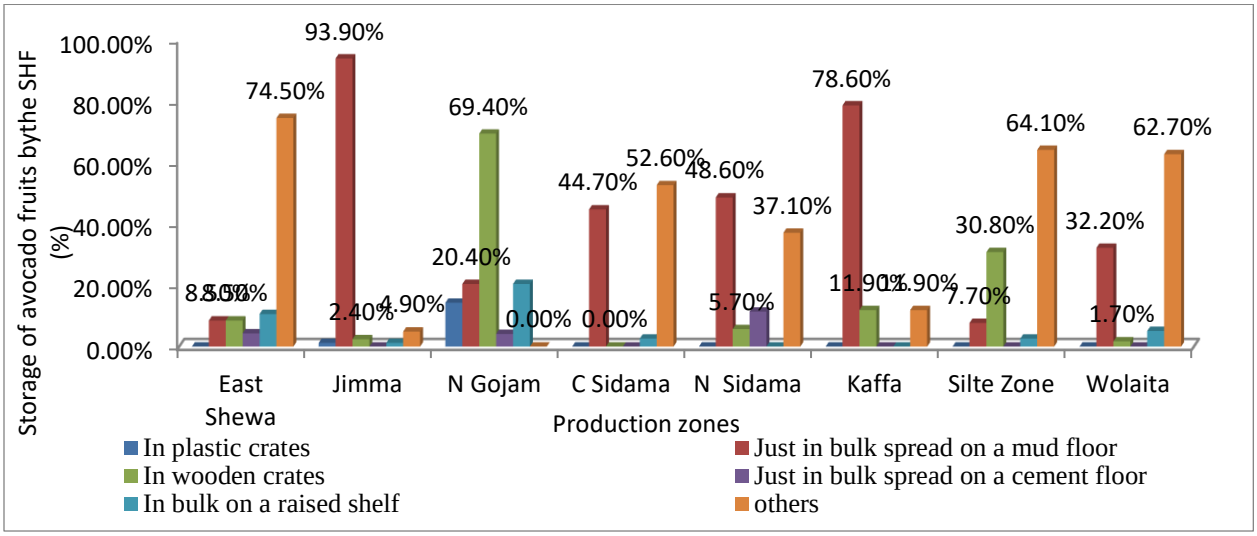

Figure 3.4. 10: Storage of avocado fruits by avocado growers after harvest

Avocado fruits are temporarily kept in a sack for a minimum of one night following their harvest prior to being transported to the local market. The storage location may vary; it can be indoors if there are concerns regarding theft, or outdoors if such issues are not present. Avocado fruits are kept indoors overnight in the Kaffa and Wolaita regions to ensure the preservation of their freshness, while in the Jimma region, the fruits are typically stored outside the home. In a similar manner, after avocado collectors and assemblers acquire the fruits from vendors along the roadside, they store the avocados in a basic shaded area beside the road until a van arrives for further transportation.

The study explored the duration of storage for avocado fruits while maintaining acceptable quality, as reported by sample growers across various regions. The findings reveal a distinct contrast between the commercial Hass variety, characterized by its thick skin and prevalent in areas such as Jimma, North Gojjam, and Silte Zones, and the local avocado varieties, which possess thinner skin and are primarily found in regions like Jimma, Kaffa, and Wolaita Zones.

The study indicated that the fruits of the Hass avocado variety can be stored with acceptable quality for a duration ranging from 11.20 days in East Shewa to 5.15 days in North Gojjam. In

contrast, local avocado varieties demonstrated a significantly shorter shelf life, maintaining acceptable quality for an average of 1.2 days in Jimma and up to 3 days in Wolaita Zones (Table 3.4.4). This finding implies that, in the absence of temperature and humidity regulation, local avocado varieties should ideally be delivered to consumers within a two-day timeframe. Furthermore, it is important to note that avocados sourced from Jimma, Kaffa, and Wolaita would not require more than a few hours to reach the central market in Addis Ababa.

Table 3.4. 4: Number of day's avocado fruits stored with acceptable quality

Region	**Zone**	Number of day's avocado fruits storage with acceptable quality			
		Average	Std. Dev	Min	Max
Oromia	East Shewa	11.20	6.0	0.0	30.0
	Jimma	1.12	2.0	0.0	7.0
	Average	12.32	8.01	0.00	37.00
Amhara	North Gojjam	5.15	3.0	0.0	12.0
Sidama	Central Sidama	7.39	2.7	0.0	15.0
	Northern Sidama	7.91	1.4	0.0	10.0
	Average	15.31	4.03	0.00	25.00
SW Ethiopia	Kaffa	2.20	2.8	0.0	7.0
Central Ethiopia	Silte Zone	8.74	2.6	0.0	15.0
South Ethiopia	Wolaita	3.00	2.5	0.0	10.0
Average		**5.84**	**2.87**	**0.00**	**13.25**

Source: Computed from Survey Data, 2024

Ghulam and Gizachew (2020) found out that the in Arba Minch area avocados maintained their quality for duration of 12 to 13 days when stored in low-cost cool chambers. In contrast, when subjected to ambient storage conditions, the fruit became unfit for market sale by the seventh day.

Given the information reported here is derived solely from avocado growers and does not include comprehensive sensory quality testing, there is a pressing need for additional studies focused on the storability of these fruits. Such studies should rigorously assess both the physical attributes and sensory characteristics of avocados, ensuring a thorough understanding of both local cultivars and the Hass variety.

3.4.5. Practice of packaging avocado fruits before temporary storage

Smallholder avocado growers who use various packaging practice of fresh avocado fruits before temporary storage uses different types of avocado fruits packaging under sample smallholder producers in different regions. The study revealed that 69.8% of the surveyed avocado producers engage in the practice of packaging their avocado fruits prior to temporary storage, while 30.2% do not implement any packaging methods for their avocados before storing them temporarily (Table 3.4.5).

Table 3.4. 5: Packaging practice of avocado fruits before temporary storage by growers

Region	Zone	Practice packaging before storage	
		No	Yes
Oromia	East Shewa	36.2	63.8
	Jimma	25.6	74.4
	Average	30.9	69.1
Amhara	North Gojjam	51.0	49.0
Sidama	Central Sidama	36.8	63.2
	Northern Sidama	42.9	57.1
	Average	39.8	60.2
South West Ethiopia	Kaffa	21.4	78.6
Central Ethiopia	Silte Zone	25.6	74.4
South Ethiopia	Wolaita	11.9	88.1
Average		30.2	69.8

Source: Computed from Survey Data, 2024

A significant majority, approximately 90.5%, of the surveyed avocado growers utilize polypropylene bags for packaging, followed by 9.2% who use various packaging materials such as plastic sheets, baskets, and cloth few farmers also use plastic crates (Figure 3.4.11). There should be improved avocado fruit packaging which maintains the quality and shelf life of the fruits including minimizing bruises on the surface of the fruits, and all supply chain actors should use crates.

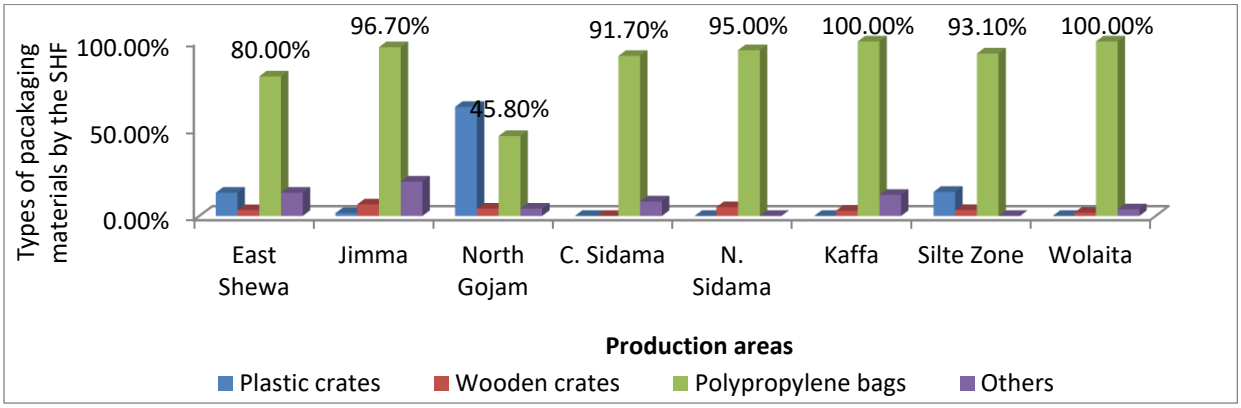

Figure 3.4. 11: Types of avocado fruits packaging used by avocado growers

There are many types of cost-effective packaging materials that can be utilized and advocated for the avocado supply chain participants in Ethiopia. Options such as perforated plastic bags and net cases are suitable for containing quantities of avocados, specifically in weights of up to 5kg. Trade companies dealing in avocados have the opportunity to use this packaging at production sites, facilitating the distribution of these packaged avocados to major supermarkets in Addis Ababa and other cities and towns across the nation. As a result, consumers of avocados will have the option to purchase these value-added and properly handled fruits at a premium price.

This information is from avocado growers and not supported with sensory quality test and evaluation, thus the number of days of avocado fruits stay in storage with acceptable quality

should be further studied with physical quality and sensory evaluation both for local types and for Hass variety.

3.5. Transportation of Avocado Fruits along the Supply Chain

Avocado fruits are bulky and perishable. Under market-oriented production system, the produce is marketed away from production areas. Thus, transportation of such fruits requires controlled atmosphere in order to keep quality and minimize losses (Hoffmann *et al*., 2012). In the studied areas, fresh fruits transportation starts after harvest from farm site; and extends to collection point, aggregation centers and local markets. Transportations of avocado fruits at all supply chain stages in Ethiopia are characterized by stacking fresh fruits in plastic sacks. From production sites to collection points, the plastic sacks are transported on the back of pack animals or animal drawn carts. Long distance transport is handled by trucks by bulking produce on the floor of the truck without any bruise protection. Under all the handling and transport means, fruits at the bottom of side of the truck are squeezed together by the weight of above fruits and are subjected external and internal damages that exacerbate loss. As the fruits are living an organ that actively respire, absence of ventilation in the plastic bags easily builds heat and accelerates ripening and loss.

Fruits harvested from clonal seed orchard of the Hass variety are less sensitive to postharvest loss due to the variety's inherent better shelf life. On the other hand, fruits derived from the highly heterogenous and traditionally managed seedling seed orchards are highly vulnerable to loss due to lack of uniformity on fruit attributes and their poor keeping quality associated to thin and soft skin.

Transportation of avocado relays through diverse actors until it reaches consumers. Among the supply chain actors in avocado marketing, producers and transporters are highly involved in transporting fresh avocado fruits from production area to the market place. Some transporters load (transport) fresh avocado fruits form Jimma, Kaffa, Wolaita and Sidama production areas to very far distance such as Dessie, Mekelle, Bahir Dar, Gonder, Harar, Jigjiga and other towns of Ethiopia where avocado is not produced. Ungraded avocado fruits from Sidama, Wolaita, Jimma and other parts of SW Ethiopia are sorted in Addis Ababa markets and shipped to neighboring countries like Djibouti and Somalia**.** Whole sellers and processing plants of avocado are the major clients of transports. In addition, retailers and producers also recruit transport service for short distance shipment of produce.

Although avocado fruits require facilities such as temperature, air, humidity control, etc... Starting from harvesting up to retailers, all avocado supply chain actors in Ethiopia do not use any facilities, thus fresh avocado fruits are transported like grain crops all over Ethiopia. This causes large quantity of fresh avocado fruits lost before reaching consumers, and if the fresh fruit reach the consumers, it is very low quality and might be with very poor hygiene and unsafe.

3.5.1. Transporting vessels for avocado fruits

Smallholder avocado growers usually transport avocado fruits are transported in bulk, in plastic crates, in wooden crates, in a polypropylene (sacks) bags from production site to local markets, collection centers and assembling points. The highest number, 89.8% of avocado growers who transport fresh fruits by Polypropylene bags; this followed by 37.7% of avocado growers who transport avocado fruits in bulk (Figure 3.5.1).

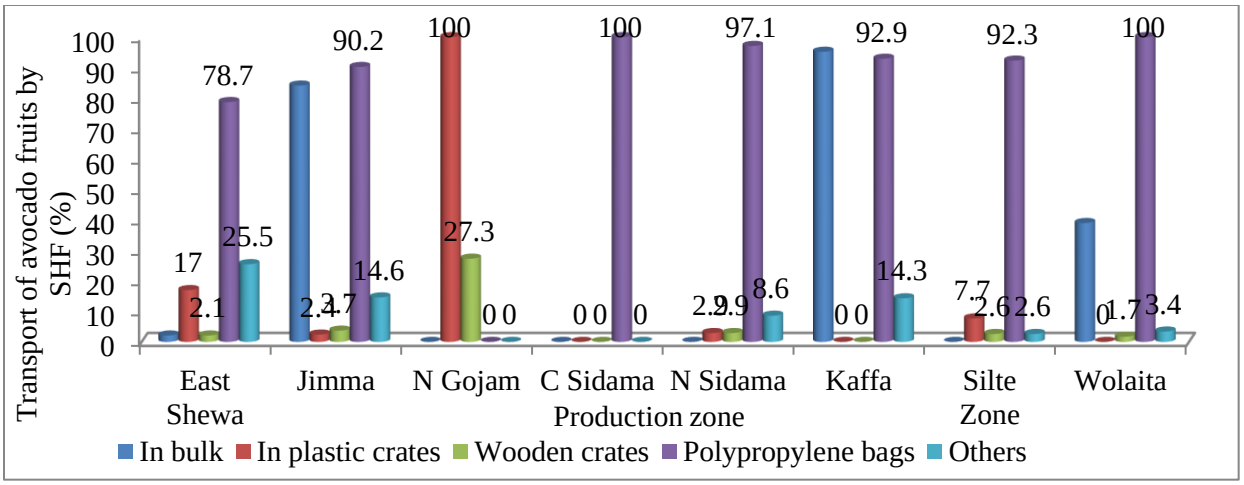

Figure 3.5. 1: Way of transport of avocado fruits by sample smallholder farmers

3.5.2. Methods of fruits packaging and transporting by transporters

In terms of fruit packaging for long-distance transport, the findings reveal that 75% of male transporters make use of plastic crates. Furthermore, 50% of the transporters are reported to use wooden crates, and another 50% choose to bulk the fruits directly onto the trucks (see Table 3.5.1). The study also highlighted that no transporters utilize polypropylene bags for the packing and loading of avocado fruits for transportation to most market destinations. Fresh avocados are generally bulked together in a densely packed manner, lacking any dedicated facilities for transport to various market locations across Ethiopia (Table 3.5.1).

Table 3.5. 1: Methods of fruits packaged for transport by transporters

Packing modality	**Sex (%)**		
	Male	Female	Total
In bulk	50.0	0.0	50.0
Plastic crates	75.0	0.0	75.0
Wooden crates	50.0	0.0	50.0
Polypropylene bags	0.0	0.0	0.0
Other	25.0	0.0	25.0

Source: Computed from Survey Data, 2024

3.5.3. Means of transport of avocado fruits by smallholder farmers

Avocado producers in Ethiopia utilize various transportation methods to convey their fruits from production regions to local markets, which include transport to collection centers and assembly points. Among means of transportations, some uses rented transport, pack animals, human back, carts, etc... According to the survey, the predominant mode of transport among growers is carts, used by 42.2% of them. This is succeeded by 37.6% who employ three wheelers and motorcycles, and 21.7% who make use of pack animals. Furthermore, 37.6% of avocado growers utilize local transportation means, such as mini-buses and similar public transport, to access the marketplace. **(**Figure 3.5.1, Table 3.5.2, Figure 3.5.3., and Figure 3.5.4). All these means of transport are not proper for fresh avocado fruits transportation, and best transportation methods should be developed.

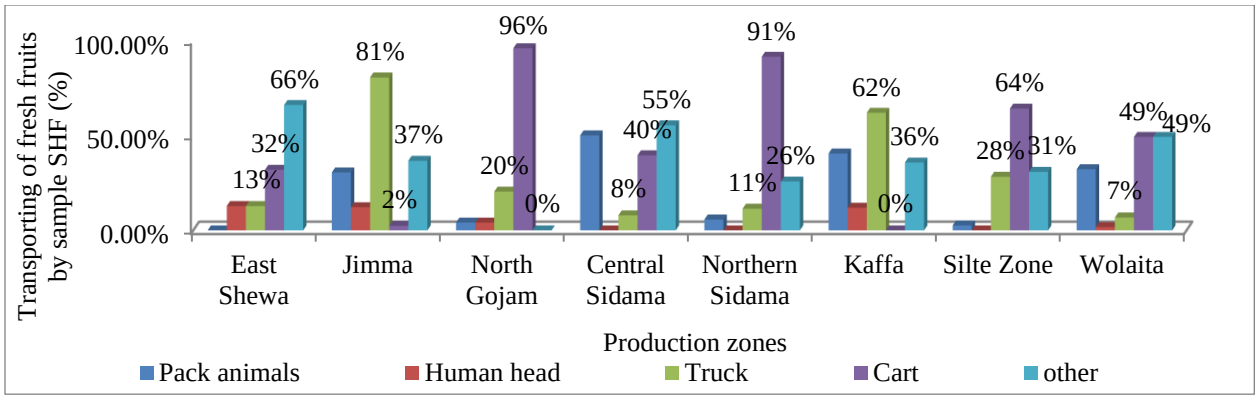

Figure 3.5. 2: Means of transporting of fresh fruits by sample avocado producers

Some transporters use their own truck and some other transporters use rented trucks commonly identified as ISSUZ and FSR for transporting fresh fruits from production areas to Addis Ababa and other Cities Central markets (Figure 3.5.3).

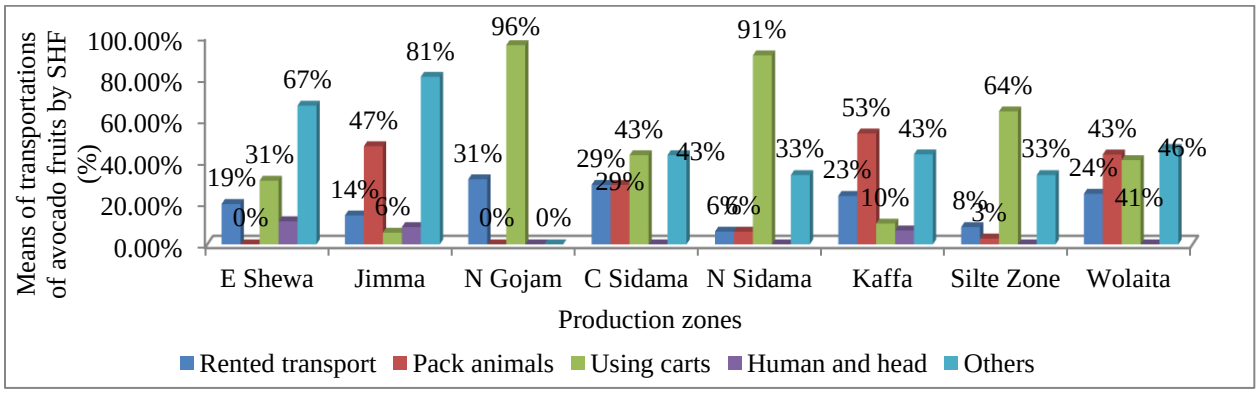

Figure 3.5. 3: Means of transportations of avocado fruits in different zones of regional states

Figure 3.5. 4: Transporting of fresh avocado fruits from farm gate to collection center

Figure 3.5. 5: Avocado fruits assemblers weighing avocado fruits

3.5.4. Distance to local avocado marketplace

Proximity to marketplaces is crucial for the production and marketing of avocados. Farmers situated near urban centers and marketplaces can easily sell their fresh avocado fruits without facing transportation challenges. The research indicated that approximately 50.1% of avocado growers live within 1-5 kilometers of local markets, while 25.6% are located within less than 1 kilometer (Table 3.5.2). Conversely, farmers in remote regions such as Kaffa, Jimma, and other areas in Southwest Ethiopia struggle to sell their avocados in local markets due to issues related to road access and the high costs or unavailability of transportation. These farmers have reported instances where market prices do not sufficiently cover transportation costs.

Avocado producers travel to the market based on the distance involved, either by personally carrying the avocado fruits or utilizing various modes of transportation. On market days, female members of the household typically transport small quantities of avocados in baskets or other containers for sale at local markets. In key production areas, particularly within the Jimma and Kaffa zones, a significant number of avocado assemblers are found along the roads during the peak harvesting season. They collect fresh avocados, which are stored in polypropylene sacks, each with a weight of 100 kg. The harvested produce is then either loaded into trucks in these sacks or transported in bulk. For long-distance transport and marketing to major market centers such as Addis Ababa, Dessie, Bahir Dar, Mekelle, and Jigjiga, the use of plastic or polypropylene bags is avoided. Many trucks gather their produce during the day and travel at night to ensure that they reach the wholesalers' warehouse in the Addis Ababa central market by the next morning. This strategy of nighttime transport is preferred to mitigate losses, as it capitalizes on the cooler night temperatures and increased humidity.

Table 3.5. 2: Distance to local avocado market place

Region	Zone	Distance to marketplace (km)					
		< 1	1-5	5-10	10-15	15-20	F) > 20
Oromia	East Shewa	29.8	36.2	10.6	19.1	2.1	2.1
	Jimma	57.3	36.6	6.1	0.0	0.0	0.0
	Average	43.6	36.4	8.4	9.6	1.1	1.1
Amhara	North Gojjam	0.0%	28.6	46.9	16.3	6.1	0.0
Sidama	Central Sidama	7.9	57.9	10.5	5.3	15.8	2.6
	N. Sidama	11.4	88.6	0.0	0.0	0.0	0.0
	Average	9.7	73.2	5.3	2.6	7.9	1.3
S West Ethiopia	Kaffa	54.8	45.2	0.0	0.0	0.0	0.0
Central Ethiopia	Silte Zone	10.3	51.3	28.2	10.3	0.0	0.0
South Ethiopia	Wolaita	8.5	72.9	16.9	1.7	0.0	0.0
Average		25.6	50.1	14.8	6.1	2.6	0.5%

Source: Computed from Survey Data, 2024

A waiting period exists between the harvesting of avocados and their transportation to market among various smallholder producers across different regions. According to the survey findings, 36.1% of avocado growers wait less than one hour, while 32.5% wait between one to two hours before delivering their produce to the local market (Table 3.5.3). It is observed that an increase in the waiting time correlates with a rise in the perishability of the avocados.

The overall time taken for transportation from harvesting to the final retail market and consumers is primarily determined by the duration necessary to assemble a complete truckload. This process is affected by multiple factors, such as the spatial distribution of avocado farms, the uniformity of fruit maturity, and the distance from the production area to the collection site, the time allocated for sorting, weighing, loading, and transporting to the aggregation center, road conditions, and inspection durations during transit, unloading times, and other factors.

Table 3.5. 3: Time required for reaching the market

Region	Zone	Maximum waiting hour between harvesting and moving to market (%)					
		< 1 hour	1-2 hours	2-3 hours	3-4 hours	4-5 hours	>5 hours
Oromia	East Shewa	38.3	19.1	2.1	0.0	2.1	38.3
	Jimma	56.1	30.5	8.5	3.7	0.0	1.2
	Average	47.2	24.8	5.3	1.8	1.1	19.8
Amhara	North Gojjam	22.4	36.7	14.3	2.0	12.2	12.2
Sidama	C Sidama	28.9	31.6	13.2	23.7	0.0	2.6
	N Sidama	31.4	11.4	31.4	11.4	0.0	14.3
	Average	30.2	21.5	22.3	17.6	0.0	8.5
SW Ethiopia	Kaffa	61.9	31.0	7.1	0.0	0.0	0.0
C Ethiopia	Silte Zone	5.1	38.5	12.8	2.6	0.0	41.0
S Ethiopia	Wolaita	27.1	52.5	0.0	6.8	1.7	11.9
Average		36.1	32.5	10.0	5.6	2.0	13.8

Source: Computed from Survey Data, 2024

3.5.5. Time taken to transport avocados to destination markets

Avocado fruits are often consumed and utilized far from their production regions. Estimation was made regarding the duration required for transporters to deliver avocado fruits from the production sites to the final market destinations. Nearly all transporters indicated that the travel time ranges from 1 to 3 hours to reach these destinations (Table 3.5.4). The transportation of avocados from the main production areas, including Jimma, Kaffa, and Wolaita, to the central market in Addis Ababa will require a significantly longer duration.

Table 3.5. 4: Number of hours required to transport avocado fruits to the destination markets

Time taken to transport the avocado fruits	Sex		
	Male	Female	Total
1-3	100.0	0.0	100.0
4-6	0.0	0.0	0.0
7-9	0.0	0.0	0.0
Total	100.0	0.0	100.0

Source: Computed from Survey Data, 2024

As trucks loaded with avocado fruits reach their target markets, including Addis Ababa and other cities across Ethiopia, the unloading process is not immediate and requires significant time. According to the findings, 75% of transporters stated that the duration for unloading typically ranges from one to two hours (Table 3.5.5).

Table 3.5. 5: Truck waiting time before unloading fruits at the destination market

Time taken to unload the fruit after reaching the final destination (Hr.)	Gender (%)		
	Male	Female	Total
<1.0	0.0	0.0	0.0
1.0 – 2.0	75.0	0.0	75.0
3.0 - 4.0	25.0	0.0	25.0
5.0-6.0	0.0	0.0	0.0
>6.0	0.0	0.0	0.0
Total	**100.0**	**0.0**	**100.0**

Source: Computed from Survey Data, 2024

3.5.6 Transport cost of avocado fruits from farm to the local market

The transportation costs to the nearest market are determined by the distance from all-weather roads; as these distance increases, so do the associated costs. Avocado growers in remote areas bear the highest transportation costs, primarily due to their reliance on traditional and unconventional transportation methods, such as pack animals and motorcycles, exacerbated by poor road conditions. Growers have indicated that for a 100 kg shipment of avocados, which is priced between 400 to 500 Birr, they incur transportation costs of 200 to 300 Birr on inaccessible roads, compared to only 40 to 100 Birr in regions with adequate road conditions (Figure 3.5.6). This situation indicates that avocado production in remote areas is not a lucrative business for smallholder farmers. Far Furthermore, farmers have reported that avocado production in regions with road access and proximity to market centers generates better income than coffee.

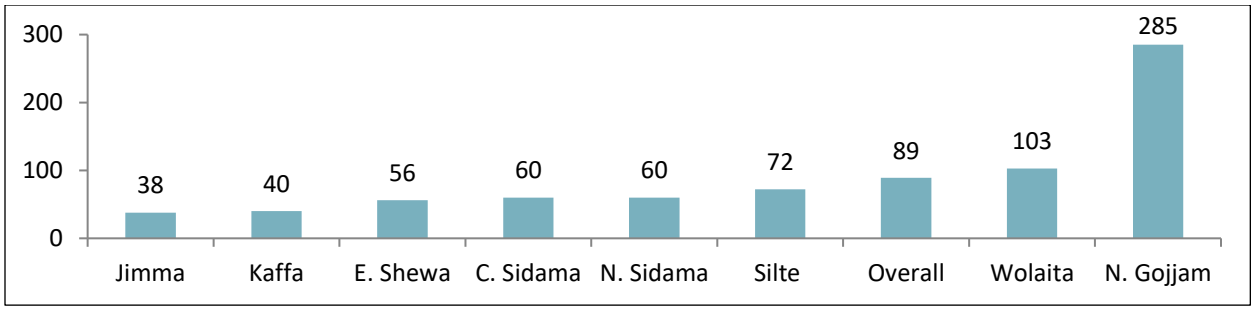

Figure 3.5. 6: Average transport cost/100kg of avocado from farm to local market

Avocado growers are remunerated for their harvested fruits either before the sale, at the moment of transaction, or up to a month later. According to the findings, 80% of avocado farmers obtain their payments at the time of the transaction (Figure 3.5.7).

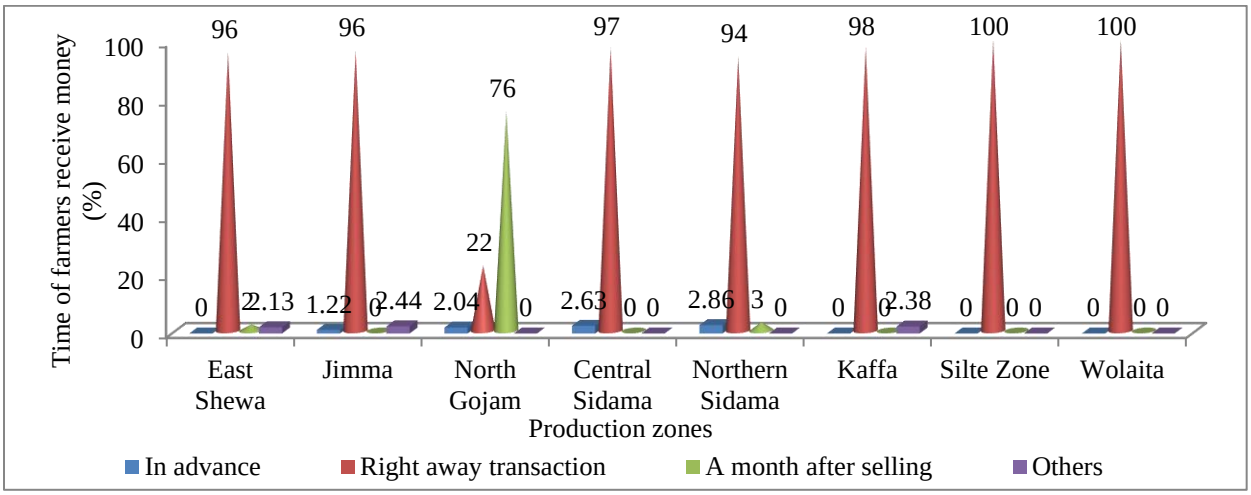

Figure 3.5. 7: Time taken for financial payment to the farmers

3.5.7. Cost of transporting of avocado fruits to Addis Ababa Central Market

The assessment conducted on the transport costs for avocado fruits from the local market to the central destination market demonstrated that the expenses fluctuate between 205 Birr and 241 Birr for each 100 kg. The cost of transporting avocado fruits from various locations in Ethiopia to the designated market is determined by multiple factors, including the distance from the production area to the market, exemplified by the route from Tulo and Cheta Woreda in the Kaffa Zone to Addis Ababa. The type of road- be it asphalted or gravel- also influences these costs, which are subject to seasonal variations. Moreover, the transportation costs for avocado fruits to other parts of Ethiopia can differ significantly. Additionally, the study identified wholesalers as the key players in determining transportation costs, followed by middlemen and producers. The transportation process is largely unregulated and significantly influenced by the negotiations between transporters and their clients.

The rental of trucks for the transportation of avocado fruits from production sites to the central market is widely practiced. The study looked into when transporters are compensated for their services. The majority of the transporters stated that they receive payment upon reaching the destination.

3.5.8. Transport cost determination

An investigation was conducted into the actors responsible for determining transportation costs. The findings revealed that wholesalers exert the greatest influence (75%) on these costs, followed closely by middlemen and producers, each contributing equally at 25%. Additionally, negotiations between the transporter and the client impact (50%) the transportation costs of avocado fruits.

3.5.9. Types of clients for transporting the avocado fruit

The transportation of avocados involves a diverse array of participants within the supply chain. This includes facilitators, brokers, intermediaries, and collectors (assemblers) who engage in discussions regarding pricing and other matters with the farmers (Figure 3.5.8). The process begins with the selection of avocado trees, which involves assessing the maturity of the fruits. Farmers whose trees are ready for harvesting are provided with sacks. The pricing of avocados is communicated, either on a per-kilogram basis in the Jimma Zone or per estimated quintal in the Kaffa Zone, where the kilogram measurement is less prevalent. Furthermore, facilitators engage children to assist with the harvesting, guide farmers in sorting the fruits, and arrange for transportation to the roadside for truck pickup. The harvested fruits are densely packed and often overcrowded within the sacks. The harvested fruits are tightly packed and frequently overcrowded in the sacks.

The analysis of client categories for avocado fruit transportation in the sample regions revealed that wholesalers and processing industries accounted for the largest share (100% each), with producers and retailers also representing (75%) of the client base.

Figure 3.5. 8: Loading, stacking and bulk transport of fresh avocado fruits to the central market

The practice of stacking and compressing fresh avocado fruits, along with the act of standing on these fruits while wearing shoes, which results in their crushing, is frequently observed during the loading process onto ISUZU/FSR trucks. This compaction and overcrowding at the collection center are a common occurrence. Fruits are loaded onto trucks and transported in a manner that is both compact and overcrowded, lacking adequate cooling and ventilation. The loading process occurs along the roadside and at marketplaces until the trucks reach their full capacity. Once the trucks, such as the ISUZU with a capacity of 60,000 kg and the FSR with 90,000 kg, are fully loaded, the driver promptly begins the journey to the central market in Addis Ababa. The driver drives through the night, arriving at the central market in Addis Ababa at dawn to unload the fruits. At all checkpoints from the collection point to Addis Ababa, officers inspect trucks by inserting a very long iron stick into the avocado fruits stacked on the vehicles,

searching for contraband items like firearms. This stick is not clean and is used for inspecting every truck, contributing to unsanitary conditions. This method destroys around 200 kilograms of avocado fruits per truck.

3.5.10. Sourcing of avocado fruits by the transporters

Of the transporters interviewed, 50% stated that they procure and collect avocado fruits from a singular source, whereas the remaining 50% indicated that they can source from multiple areas,

3.5.11. Quantity of avocado fruits moved per single transport

An assessment was conducted on the volumes of avocado fruits transported to market destinations for each trip. The results indicated that the volume of fresh avocado fruits transported by trucks ranges from 1000 kg-4000kg.

3.5.12. Frequency of transporting of avocado fruits

An evaluation of the frequency with which avocado fruits are transported by selected transporters annually indicated that 75% of these transporters make between 7 to 10 trips per year, while 25% exceed 10 trips annually. The frequency of transportation is influenced by the availability of avocado fruits in the region; in areas where fruits are consistently available throughout the season, such as Kaffa, there is a greater likelihood of frequent transportation. However, there is a lack of data regarding the number of transporters operating in each Woreda, Zone, and region. Additionally, there is insufficient information on the quantity of avocados transported weekly and monthly by transporters across all Woredas. A national database detailing the avocado business operations within the country is necessary.

3.5.13. Transporters access to avocado owners (clients)

The survey engaged transporters to explore how they establish communication with private owners (clients) of avocado orchards and plantations in various sample zones throughout different regional states of Ethiopia. The findings demonstrated that the largest proportion of producers directly reach out to transporters themselves, with an equal 50% of transporter respondents indicating that they either actively search for and contact producers or receive inquiries from brokers and middlemen.

The transportation network for avocados across various regions is characterized by well-structured systems that connect each transporter with avocado producers. Numerous stakeholders operate between the transporter and the producers. In rural marketplaces and along roadways, many collectors, also known as assemblers, are present. Additionally, several intermediaries supply sacks to farmers, assess the maturity of avocado trees and fruits and assist in the harvesting process, including the sorting of damaged fruits. In instances where families lack children to assist with harvesting, these intermediaries and collectors may resort to hiring child laborers capable of climbing tall trees. The costs associated with harvesting are typically deducted from the price that the intermediaries will pay to the farmers for their avocados. A diverse array of actors is engaged in the loading of avocados, including those who 1) search for trees and facilitate the harvesting process, 2) a team that prepares, sorts, and packs the avocados into sacks, and 3) individuals responsible for loading the prepared sacks onto the truck.

3.5.14. Time of the day avocado fruits are loaded onto the trucks

Fresh avocados are loaded onto trucks from various sources, including local markets, collection and assembly points, and directly from farmers along the roadside as the trucks move. The survey revealed that the largest proportion of transporters, at 75.0%, load their goods in the evening, while 50% of the respondents reported loading in the early morning.

There is currently no established standard for the loading of fruits onto trucks. The collection of avocado fruits, which are packed in sacks, is undertaken by transporters who gather them from various assemblers or collectors. This process begins in the early morning and continues through the noon and late afternoon, extending into the evening. The transport then proceeds throughout the night to reach Addis Ababa and other central markets.

3.5.15. Protection of avocado fruits from damage during transportation

The delicate and perishable nature of avocado fruits necessitates stringent protective measures from the time of harvesting through packing and all subsequent handling until they reach consumers. Therefore, it is imperative to exercise extreme caution during the transportation process from production facilities to central market locations. According to survey results, there is a notable absence of protective protocols for avocados during transit, which increases the risk of damage and contamination. It is advisable for the fruits to be covered with a clean canvas and to be transported independently from other items. Furthermore, the loading floors of all trucks should be meticulously cleaned to remove any potential contaminants. Among the transporters surveyed, a significant proportion avoids transporting avocados with other goods and ensures that the loading floors of their trucks are clean, in addition to covering the fruits with a clean canvas (Table 3.5.6). It is imperative to exercise caution when loading, transporting, and unloading avocado fruits. The fruits should be handled with utmost care throughout the supply chain, in accordance with numerous international guidelines established for this purpose (Hoffman *et al*., 2012; EHPEA, 2013a-g).

Table 3.5. 6: Contact channel; time of avocado fruit loading, handling/ care during transport

	Response	**%**
Contact channel with the avocado owners	Transporter search and contact producers	50.0
	Producers themselves contact transporter	100.0
	Brokers middlemen contact transporters	50.0
	Others	25.0
Time of avocado fruits loaded	Early morning	50.0
	At noon	0.0
	Late afternoon	25.0
	Evening	75.0
	Anytime	0.0
Handling/ care during transport	Cover fruits with a clean canvas	75.0
	Avoid transporting with other goods	100.0
	Clean the loading floor of any contaminant	100.0
	No much care is taken	0.0

Source: Computed from Survey Data, 2024

Avocado fruits experience decay and bruising of the flesh, which ultimately results in rot. Such deterioration is largely due to substandard harvesting techniques and improper PH handling.

According to the study, 75% of transporters acknowledge that rot and decay are the outcomes of cumulative inefficiencies within the supply chain.

3.6: Marketing of Avocado Fruits along the Domestic Supply Chain

Marketing is the process of planning and executing the conception, pricing, promotion, and distribution of ideas, goods, services, organizations, and events to create exchanges that will satisfy individual and organizational objectives. Marketing is one of the most important factors determining the success of any fruit farming enterprise.

Avocado production is predominantly concentrated in Southern Ethiopia, particularly in Wolaita, Gedeo, and Gamo, as well as in Sidama and the southwestern regions such as Kaffa and Mizan-Teppi. Additionally, Gambella, specifically Majang, and various administrative zones within Oromia, including Jimma, Buno Bedele, and Illuababora, contribute to avocado production. The regions of Amhara, Benshangul-Gumuz, and Tigray also produce avocadoes. The avocados are marketed and shipped to regions with significant demand, such as Addis Ababa, Adama, Harar, and other distant cities and towns throughout Ethiopia. Moreover, some quantities of avocados are delivered to smaller towns, making it nearly impossible to find a town in Ethiopia without access to avocado fruits.

3.6.1. Marketing of Avocado Fruits by the Smallholder Growers

3.6.1.1 Price of Avocado fruits for different grades and varieties

The cost of avocado fruits can differ depending on whether they are classified as commercial or local varieties, with commercial varieties typically fetching higher prices. Commercial varieties, such as Hass and Ettinger, are predominantly grown in the East Shewa, North Gojjam, and Silte Zones, while local mixed varieties are primarily grown in the Jimma, Kaffa, Wolaita, and Gedeo Zones.

The findings of the study show that the Grade 1 Hass avocado variety is priced at 38 Birr per kilogram in East Shewa, 25.8 Birr per kilogram in North Gojjam, and 48 Birr per kilogram in the Silte zone (Figure 3.6.1). The cost of similarly graded avocados in the Jimma Zone is 7.8 birr per kilogram, in contrast to 7.6 birr per kilogram in Kaffa. Prices fluctuate according to the season, with higher costs during the off-season and much lower prices during the extended peak supply period. This underscores the need for a nationwide grading system for avocados and the promotion of awareness throughout every stage of the supply chain.

The price of avocado fruit is also influenced by the distance from central markets. When the production area is located far from Addis Ababa and other distant cities, transporting fresh fruits, including the Hass variety, becomes challenging due to their bulkiness and perishability. Additionally, this situation is occasionally exacerbated by security issues, as trucks laden with avocados may spoil along the highway when routes are obstructed for various reasons

In general, avocado fruits are priced at a premium, with the Silte Zone exhibiting the highest prices, succeeded by East Shewa. On the other hand, Jimma and Kaffa offer these fruits at much lower prices (Figure 3.6.1).

Due to the variability in size, color, and taste of avocado fruits, particularly among local mixed-grade categories for pricing purposes. The prices differ according to these grade categories, with Grade I averaging 21.3 Birr per kilogram, Grade II at an average of 12 Birr per kilogram, and

Grade III priced at 3.7 Birr per kilogram (Figure 3.6.1). Additionally, most street vendors who sell avocados sort their products into these graded categories, reflecting the corresponding price differences. It is important to note that there is no established national standard for avocado grading and pricing in Ethiopia.

While the kilogram serves as a standard unit in numerous marketplaces, it is not adopted across the entire Kaffa Zone in Southwestern Ethiopia, where estimates are frequently employed as a unit of measure.

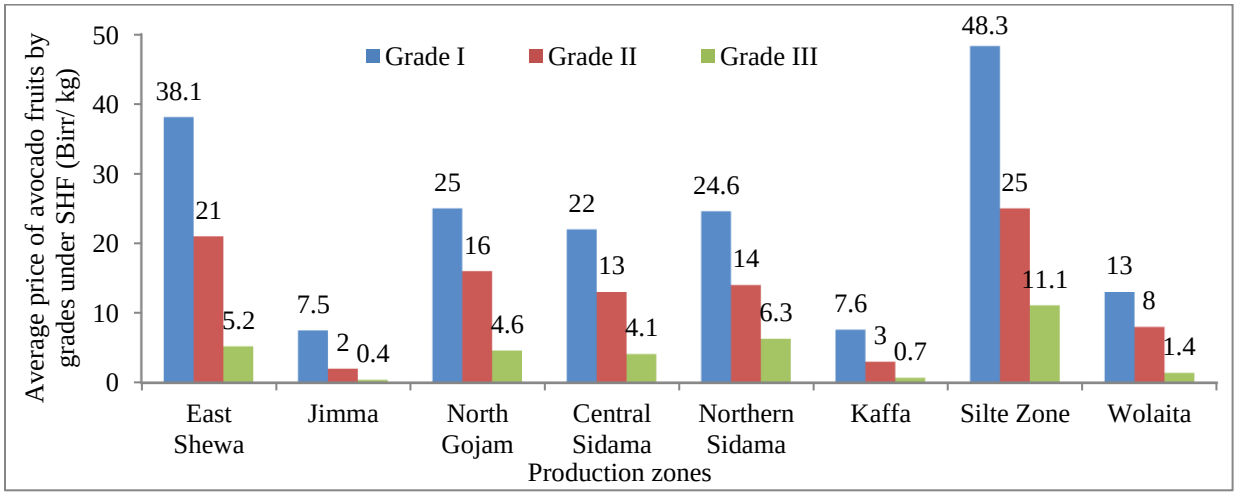

Figure 3.6. 1: Average price of avocado fruits by grades

3.6.2. Channels for selling avocado fruits

Smallholder avocado producers market their fruits through various sales channels. Some choose to sell directly from their farms, while others opt for locations in nearby cities. Additionally, certain growers sell their produce through farmers' organizations, and some send their harvests to Addis Ababa. The study revealed that a significant portion of these producers, specifically 74.6%, sell their fresh avocados in the city adjacent to their farms. In contrast, 52.4% sell directly at the farm, and 12.1% utilize the farmer's Primary Cooperative Associations for their sales (Figure 3.6.2).

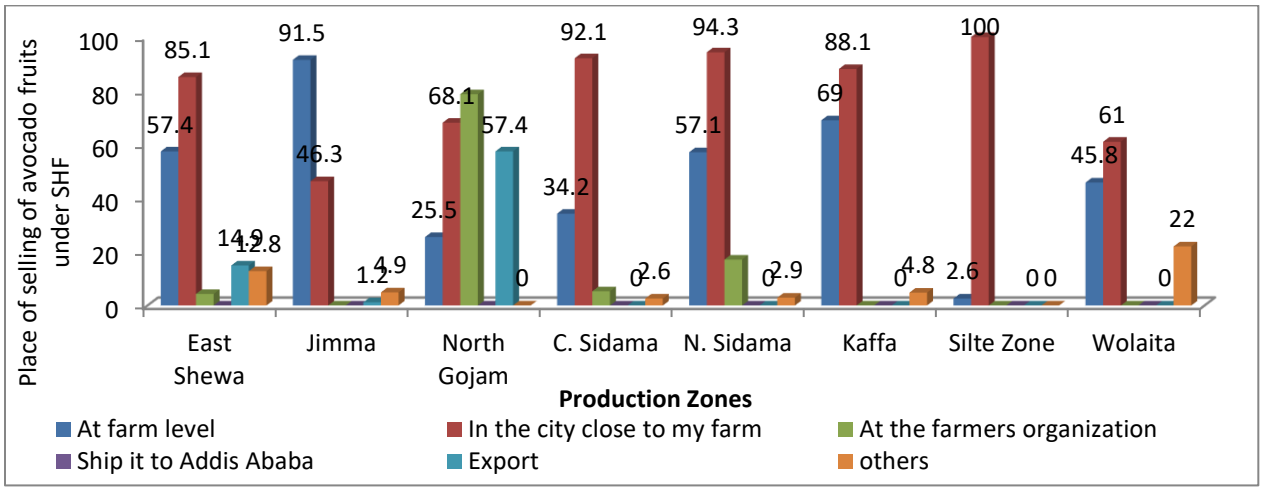

Figure 3.6. 2: Selling channels of avocado fruits by sample smallholder producers

3.6.3. Buying avocado fruits from farmers

A diverse array of avocado traders, including wholesalers, retailers, supermarkets, the processing industry, middlemen, consumers, and farmers' organizations, purchase avocado fruits from farmers. The study's results demonstrated that wholesalers represent the majority of avocado buyers at 71.5%, followed by middlemen at 65.1% and retailers at 43.6% (Figure 3.6.3).

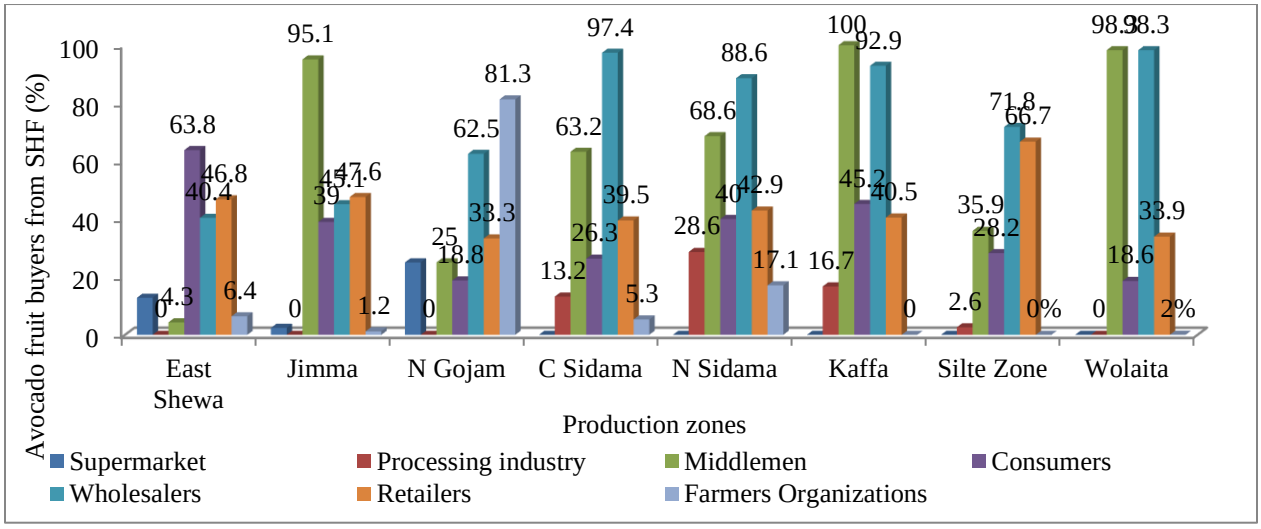

Figure 3.6. 3: Avocado fruit buyers from sample smallholder producers

3.6.4. Amounts of avocado fruits sold at any one time by farmers

The sale of avocados by farmers occurs in different quantities and at various times. According to the study, the majority of producers, accounting for 44.8%, sell an estimated 500-1500 kg of avocado fruits, with 30.9% of growers selling less than 500 kg at once (Table 3.6.1). Additionally, women frequently sell small amounts of avocados to purchase essential household items, although these transactions are difficult to quantify.

Table 3.6. 1: Amounts of avocado fruits sold at any one time by avocado producers (%)

Region	Zone	Amount sold each time				
		<500Kg	500-1500Kg	1500-2000Kg	2000-2500Kg	>2500Kg
	East Shewa	55.3	10.6	2.1	4.3	27.7
Oromia	Jimma	30.5	61	6.1	2.4	0
	Average	42.9	35.8	4.1	3.3	13.8
Amhara	North Gojjam	11.9	61.9	23.8	2.4	0
	Central Sidama	10.2	46.9	8.2	16.3	16.3
Sidama	Northern Sidama	31.6	39.5	2.6	2.6	23.7
	Average	20.9	43.2	5.4	9.5	20
SW Ethiopia	Kaffa					
C. Ethiopia	Silte Zone	48.7	17.9	7.7	2.6	23.1
S. Ethiopia	Wolaita	25.4	72.9	1.7	0	0
	Average	30.9	44.8	6.6	5.4	12

Source: Computed from Survey Data, 2024

3.6.5. Frequency of avocado fruits selling by farmers

Avocado growers typically market their fresh produce to a range of buyers, contingent upon the volume of their harvests. The research indicated that a significant portion of avocado producers, specifically 37.3%, sell their fresh fruits three times annually, while 35.5% of the growers engage in sales twice a year (Figure 3.6.4).

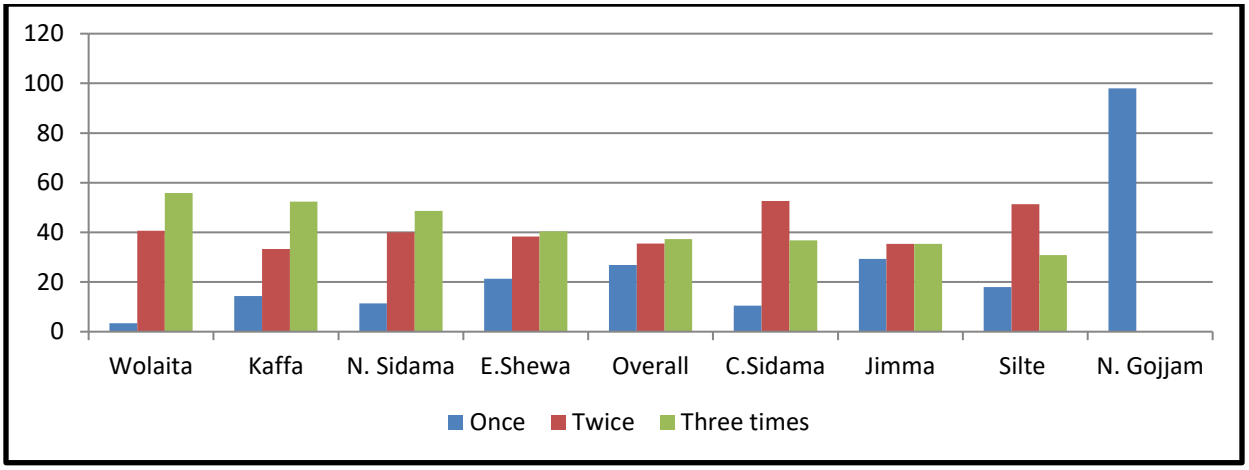

Figure 3.6. 4: Frequency of avocado selling by sample avocado growers

3.6.6. Market linkage initiation between growers and buyers

In the study areas, 17% of avocado growers actively seek out markets for selling their fresh fruits, while 13.6% are approached by buyers. The majority, comprising 69.1%, either search for buyers or are sought after by them (Table 3.6.2).

Table 3.6. 2: Market linkage initiation between growers and buyers

Region	Zone	Frequency of respondents (%)		
		Growers find buyers	Buyers find growers	Both ways
Oromia	East Shewa	36.2	21.3	42.6
	Jimma	3.7	24.4	72
	Average	19.9	22.8	57.3
Amhara	North Gojjam	16.3	0	81.6
Sidama	Central Sidama	31.6	7.9	60.5
	Northern Sidama	25.7	5.7	68.6
	Average	28.6	6.8	64.5
S. West Ethiopia	Kaffa	0	35.7	64.3
Central Ethiopia	Silte Zone	46.2	0	53.8
South Ethiopia	Wolaita	0	5.1	94.9
Average		17.1	13.6	69.1

Source: Computed from Survey Data, 2024

3.6.7. Avocado price determination at producers' level

Avocado farmers are generally poorly organized in their efforts to negotiate prices and contracts with larger buyers. Even when they are part of cooperatives, they frequently do not meet the market's requirements regarding the quality and quantity of avocado fruits. Seasonal price declines are common, especially during July and August, due to an excess supply. The market predominantly operates informally, with significant authority held by market collectors and brokers. Pricing is usually established through mutual agreements between traders and growers. Furthermore, even when producers are aware of markets that offer higher prices, they often lack the necessary access to these markets. Implementing contract farming could provide a means for farmers to secure better market positions.

The study revealed that 75% of the avocado price at the farm gate and the local market price is determined by wholesalers (Table 3.6.3). Consequently, avocado producers have minimal influence over price setting. This finding highlights that the farmers in the avocado marketing system are subjected to unfair pricing practices and are unable to negotiate their prices.

Table 3.6. 3: Avocado fruits price determination among different actors

Region	Zone	Who determine the price (%)			
		Middlemen	Wholesaler	Growers	Negotiation
Oromia	East Shewa	50	100	0	0
	Jimma	0	100	0	50
	Average	25	100	0	25
Amhara	North Gojjam	0	100	66.7	0
Sidama	Central Sidama	0	50	0	50
	N. Sidama	50	50	0	50
	Average	25	50	0	50
SW Ethiopia	Kaffa	0	100	0	0
C. Ethiopia	Silte	0	0	0	100
S. Ethiopia	Wolaita	0	100	50	50
Average		12.5	75	18.8	37.5

3.6.8. Market quality determination of avocado fruits

It is crucial to maintain market quality that meets the requirements of buyers in order to optimize the selling prices for sellers. Avocado fruit has distinct market qualities that appeal to consumers. The postharvest quality and shelf life of avocados are influenced by many factors for example temperature, which increases during the respiration process that occurs in ripening and produce ethylene (Wright, *et al*., 2013).

The overall quality of avocados is determined by various attributes, including aroma and flavor. Commercial quality distinction systems for avocado fruits are based on extrinsic attributes of the product, for instance: shape, color, size, weight, and blemishes. Fresh avocados should at least

be intact, clean, and free from pests, free from damage, free of abnormal external moisture, have a stalk no longer than 10 mm in length, and be in a condition to withstand transport and handling size and packaging. Avocado shelf life can also be affected by packaging materials at the end of the ripening period in case actors use a carton with a poly sheet (Nardos and Wakgari, 2016). Avocados must at least be packed in new, clean, and quality packaging to prevent damage and protect the product properly (CBI, 2017).

Harvesting mature fruit is crucial to ensure that fruit has an acceptable eating quality and will ripen effectively. Avocado oil content and dry matter determine eating quality and increase as the fruit develops to maturity. As per UNECE, (2017) standards, dry matter content for Hass varieties should not go below 21% and Fuerte 20%. However, avocado product standards may differ per country and variety. The size for fresh avocados is classified according to 1 to 30, with a minimum weight of 123 grams (or for Hass 80 grams). In Europe, the preferred sizes for Hass avocados range between size 16 and 20 (for the Fuerte variety 14 to 16) (CBI, 2017).

The study found that 53% of respondents prioritize the size of the fruit, 15% consider its maturity, and nearly 12% focus on color, with a clear preference for dark-skinned avocados compared to green ones (Figure 3.6.5).

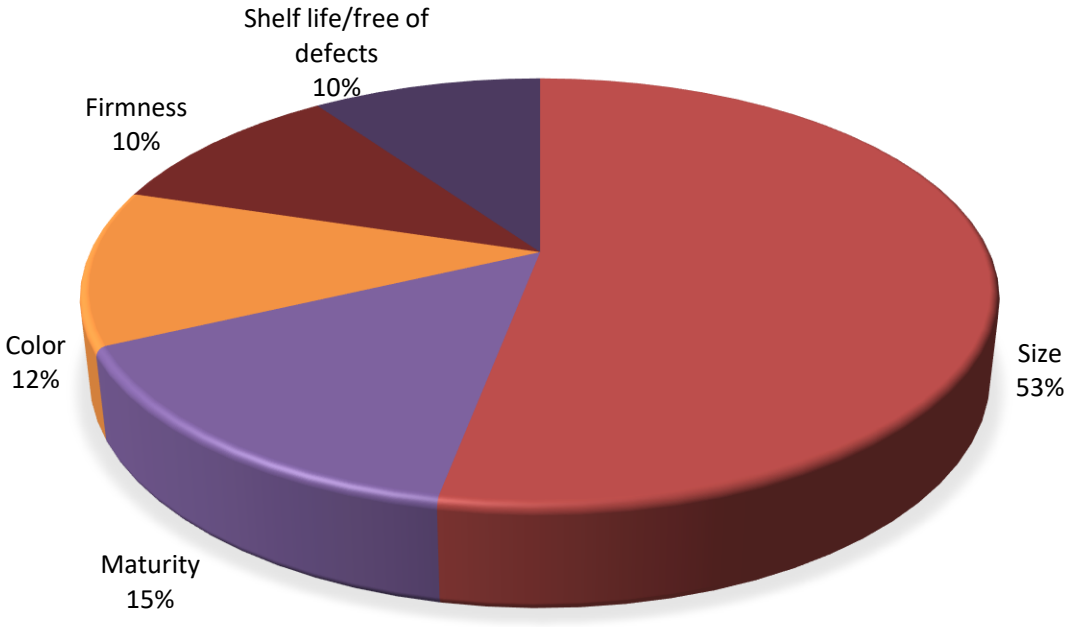

Figure 3.6. 5: Quality criteria of avocado in the local market

There are different global standards that Ethiopian avocado shall fulfill in order to make an export. Some of these are UNECE Minimum Quality Specifications, International Standards for Fruit and Vegetables (OECD), Fair-trade, BRC Global Standards, ES ISO 9001:2015 – QMS, ES ISO 22000:2018- FSMS, ES ISO 26000, a standard for social responsibility, ES ISO 14001 for Environmental management, and Good agricultural practices for production of fresh fruit and vegetables in ASEAN countries (ASEAN GAP). In addition, harvesting, transporting, packhouse operations should follow standard protocols. Consequently, there is a need for an organization that supports avocado production, marketing, and export in a manner that meets the standards of the international market.

3.6.9. Marketing margins of avocado in different channels

Avocados produced by farmers pass from one actor to another, each of whom improves the product quality by sorting and the creation of time utility, while also incurring certain costs. In the avocado supply chain, wholesalers capture the largest share of the market margin at 32.2%, and the highest profit margin at 39.64%.

When comparing the marketing margins of other participants to those of wholesalers, exporters account for 21.8%, collectors/assemblers for 14.1%, producers for 12.8%, urban retailers for 12.4%, and rural retailers for 6.7%. In terms of profit margins, exporters receive 22.83%, urban retailers 14.11%, collectors 12.81%, producers 7.54%, and rural retailers 3.07% (Table 3.6.4).

As presented in Table 5.4, there are notable discrepancies in the prices customers pay across various market channels, with wholesalers achieving the highest gross marketing margin of 32.2% and rural retailers the lowest at 6.7%. When avocados were sold to consumers through rural retailers, only 9% of the price was added. This suggests that a widening market margin leads to higher prices for consumers, while producers continue to enjoy lower pricing.

Of all actors, producers achieved the highest gross merchandise margin (GMM) of 91% in the rural retail channel when selling directly to consumers although this channel featured minimal avocado advertising. Producers received the lowest GMM in the channel of wholesalers at 56.6%. The highest NPM was found in the channel of wholesalers at 39.64%, and the lowest NPM was found in the channel of rural retailers at 3.07% (Table 3.6.4). Of all actors, producers have the lowest profit margin (7.54%) in the channel when she/he sells avocados direct to consumers. The distribution of profit margin among actors in each channel showed significant differences and a relatively unfair distribution

The wholesale channel yielded the lowest Gross Margin Margin (GMM) for producers, which stood at 56.6%. The highest Net Profit Margin (NPM) was also recorded in this channel, at 39.64%, while the rural retail channel exhibited the lowest NPM of 3.07%. According to Table 5.4, the 39.64% profit margin in the wholesale channel is the highest, whereas the rural retail channel's 3.07% reflects the minimum profit margin. Producers, when selling avocados directly to consumers, realized the lowest profit margin of 7.54% among all actors (Table 3.6.4). Overall, the profit margin distribution across different actors in each channel reveals significant variations, suggesting a relatively inequitable distribution.

Table 3.6. 4: Marketing margins of avocado in different channels

Avocado business type	Average Purchasing Price ETB/Kg	Average selling price ETB/Kg	Market cost	Gross margin ETB/Kg	% Of GMM	GMM_P	% Of profit margin
Producers	7.3	13	2.63	7.7	12.8	82.8	7.54
Rural retailers	14.5	18.5	2.75	4	6.7	91	3.07
Collectors/Assemblers	14.5	23	3.28	8.5	14.1	81	12.81
Wholesalers	20	39.5	3.35	19.5	32.2	56.6	39.64
Urban retailers	35	42.5	1.75	7.5	12.4	83.3	14.11
Exporter	32.3	45.5	3.9	13.2	21.8	70.6	22.83
Consumer	45	_	_	_	_	_	_

3.6.10. Determinants of avocado quantity supplied to the market

The findings from multiple linear regression models utilized to determine the factors affecting the supply of avocados to the market indicated that some of the major influences are the distance to the market, the quantity of avocados produced, the price at which avocados are sold during the harvest season, and the overall quality of the product (Table 3.6.5).

Distance to the nearest market: The distance from the nearest market negatively and significantly impacts the supply of avocados, causing a decline of 5.1 quintals (0.051) in the quantity supplied. This suggests that decreased distance to the market heightens the motivation of avocado producers in terms of their production and distribution channel choices. A closer market leads to reduced transportation costs, shorter walking times, lower marketing costs, and better access to market information and facilities.

Quantity of avocados produced: - The volume of avocado production significantly influenced the amount of product supplied to the market. If all other conditions are kept constant, an increase of one quintal in avocado production leads to a corresponding increase of 0.281 quintals in the quantity marketed.

Price of avocado during harvesting: - The analysis indicated that the price of avocados significantly and positively affects the supply in the avocado market. When other exogenous variables are maintained at their average levels, a one ETB increase in the price of avocados results in a supply increase of 0.048 quintals. The results also demonstrate that household income has a positive effect on the supply of avocados.

Quality of the avocado products: - The quality of the product has had a notable and beneficial effect on the market supply of avocados from producers. Farmers who offer high-quality avocados are more inclined to supply fruit that meets market standards compared to those who do not. Consequently, the market supply from these farmers rose by 0.022 quintals when they delivered quality products.

Table 3.6. 5: Determinants of avocado quantity supplied to the market during the study period

Model	Coefficients	Std. Error	t	Sig.
(Constant)	8.276	5.207	1.114	.267
Experience in avocado growing (years)	0.128*	1.767	1.348	.079
Sex of HH head (1=Male)	0.527	0.187	.807	.421
Education level of HH head	0.205	0.113	.076	.939
Distance to the nearest market in KM	-0.051*	0.178	-.721	.072
Distance to the nearest all weather road in KM	-0.061	0.042	-.873	.384
Total land owned (ha)	1.326**	6.772	.362	.018
Livestock ownership	-0.410	0.322	-.149	.882
Area of avocado grown by farmer (ha)	0.606**	0.843	.057	.054
Irrigated avocado farm in hectare	0.022**	0.098	2.308	.022
Number of avocado trees	0.253**	0.155	2.075	.039
Quantity of avocado harvested	0.281***	.029	3.950	.000
Price of avocado during harvesting	0.048*	0.631	.689	.092
Received income from off farm	-0.603	2.879	-.093	.926
Types of variety (1=Improved)	0.033*	0.191	1.691	.093
Market information access (1=yes)	0.378**	0.529	.978	.032
Prob> F = 0.0000	R-squared = 0.515			

3.6.11. Volume of avocado fruits sales per month

The findings of the study reveal that the volume of avocado fruit sales fluctuates monthly across different zones, with Kaffa achieving the highest sales at 280,000.00 kg per month. Jimma follows with an average monthly sale of 154,000.00 kg, as shown in Table 3.6.6. East Shewa, however, reported the lowest sales volume, with only 6,000 kg of avocado fruits sold each month.

Table 3.6. 6: Estimated volume of avocado sale per year by sample households

Region	Zone	Volume of sales per month (kg)			
		Mean	Std Dev	Minimum	Maximum
Oromia	East Shewa	6000	5657	2000	10000
	Jimma	154000	15563	44000	264000
	Average	80000	80610	23000	137000
Amhara	N. Gojjam	10440	16943	320	30000
Sidama	C. Sidama	75000	21213	60000	90000
	N. Sidama	98000	87681	36000	160000
	Average	86500	54447	48000	125000
SW Ethiopia	Kaffa	280000	5754	150000	480000
C. Ethiopia	Silte	26000	31113	4000	48000
South Ethiopia	Wolaita	62250	774282	75000	117000

3.6.12. Avocado purchasing and selling prices

The estimated purchasing price, selling price, and revenue for avocado fruits in different production zones and regions of Ethiopia are detailed in Table 3.6.7.

Purchasing price: The study found that the purchasing price of avocado is highest in North Gojjam at 3437.5 Birr per 100 kilos followed by East Shewa at 2200.00 Birr per 100 kilos, and followed by North Sidama at 1850.00 Birr for 100 kg of fruits. In the Wolaita zone, the purchasing price for avocados stands at 963.25 Birr per 100 kilograms. The higher prices observed in North Gojjam and East Shewa is primarily due to the dominance of the Hass variety, which is in high demand both domestically and for export. In contrast, the lower prices in Wolaita result from the prevalence of locally grown mixed avocado varieties (Table 3.6.7).

Selling price: The study indicated that avocado fruits in the Silte Zone command the highest market price, reaching 7000.00 Birr for every 100 kilograms. This is followed by North Gojjam, where the selling price is 6083.3 Birr per 100 kilograms. In contrast, the lowest selling price for avocado fruits, at 2050 Birr per kilogram, is observed in both the Central and North Sidama zones (Table 3.6.7).

Revenue: The Silte Zone generated the highest revenue from avocado sales, achieving 5243.7 Birr per 100 kilograms, while the Wolaita Zone followed with revenue of 3086.7 Birr per 100 kilograms of avocado fruits.

Table 3.6. 7: Average purchasing and selling price, and revenue from avocado Birr/100 kg

Regions	Zones	Purchasing price	Selling price	Revenue
		Mean	Mean	Mean
Oromia	East Shewa	2200.00	3500	1300.00
	Jimma	1010.25	3200	2189.7
	Average	1605.13	3350	1744.87
Amhara	North Gojjam	3437.5	6083.3	2645.8
Sidama	Central Sidama	1175.00	2050	875.00
	N. Sidama	1850.00	2050	200.00
	Average	1612.5	2050	337.50
SW Ethiopia	Kaffa	1500.00	2100	600.00
Central Ethiopia	Silte	1756.25	7000	5243.7
South Ethiopia	Wolaita	963.25	4050	3086.7
	Overall men	1845.9	3893.8	2047.9

3.6.13. Mapping avocado value chain, market and distribution channels

The main actors involved in the fresh avocado marketing system are producers, rural assemblers, wholesalers, retailers, brokers and consumers. A large contingent of supplying farmers is prevalent in the markets at the farm level. Transporters purchase fruits from producers, rural collectors and assemblers, and subsequently sell the avocados to wholesalers in Addis Ababa (Figure 3.6.6 & 3.6.7).

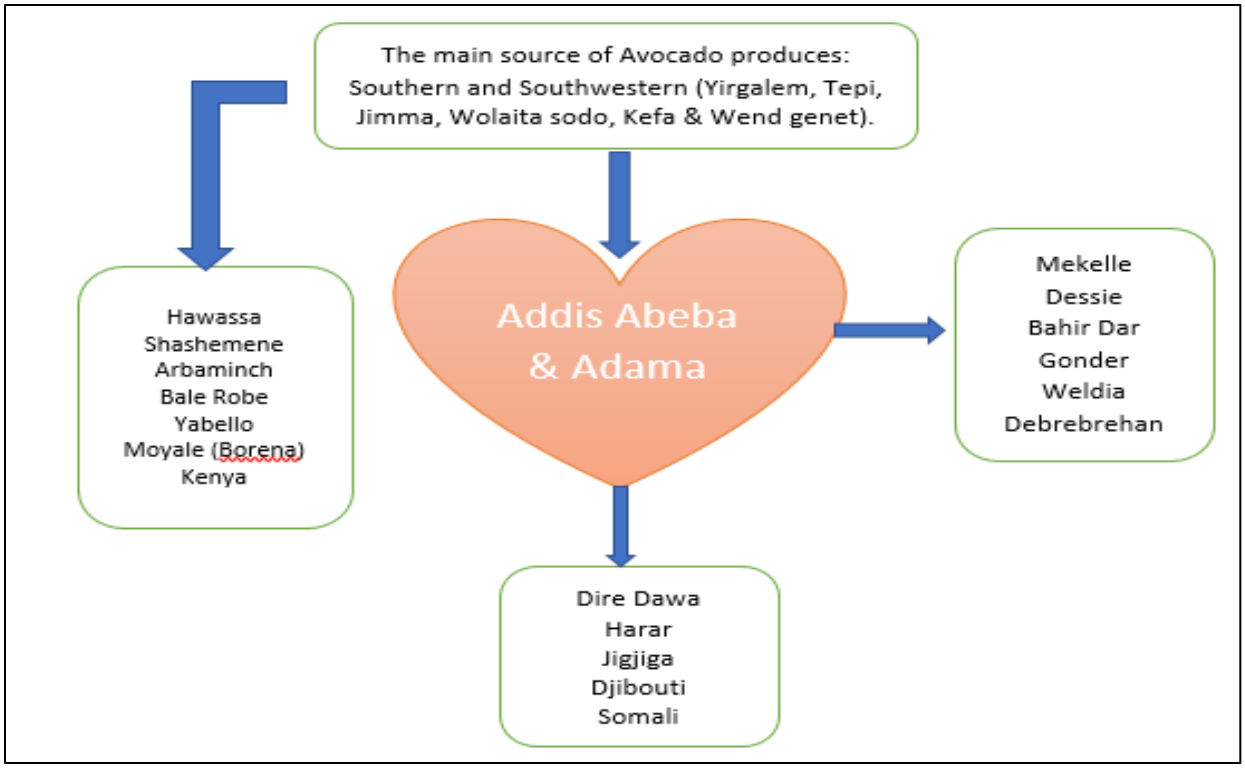

Figure 3.6. 6: Avocado marketing routes in Ethiopia

Wholesalers distribute avocados to various retailers, juice houses, restaurants, and, to a lesser degree, to street vendors and individual consumers. Derib *et al*, (2014) identified seven market channels (lines) for avocado fruits marketing in 'Damot Gale' and 'Boloso Bombe' Districts of Wolaita Zone (Table 3.6.8). An eighth channel, which involves the transfer of avocados from farmers to oil processors, has now been added.

Table 3.6. 8: Avocado market channel participants

Channel	Participant
Channel 1	Farmer – Consumer
Channel 2	Farmer – Retailer –Consumers
Channel 3	Farmer –Rural assembler - Wholesaler – Consumers
Channel 4	Farmer –Wholesaler – Retailer – Consumer
Channel 5	Farmer –Rural assembler—Retailer—Consumer
Channel 6	Farmer-- Rural assembler—consumer
Channel 7	Farmer – Wholesaler – Consumers

Source: Derib et al, (2014)

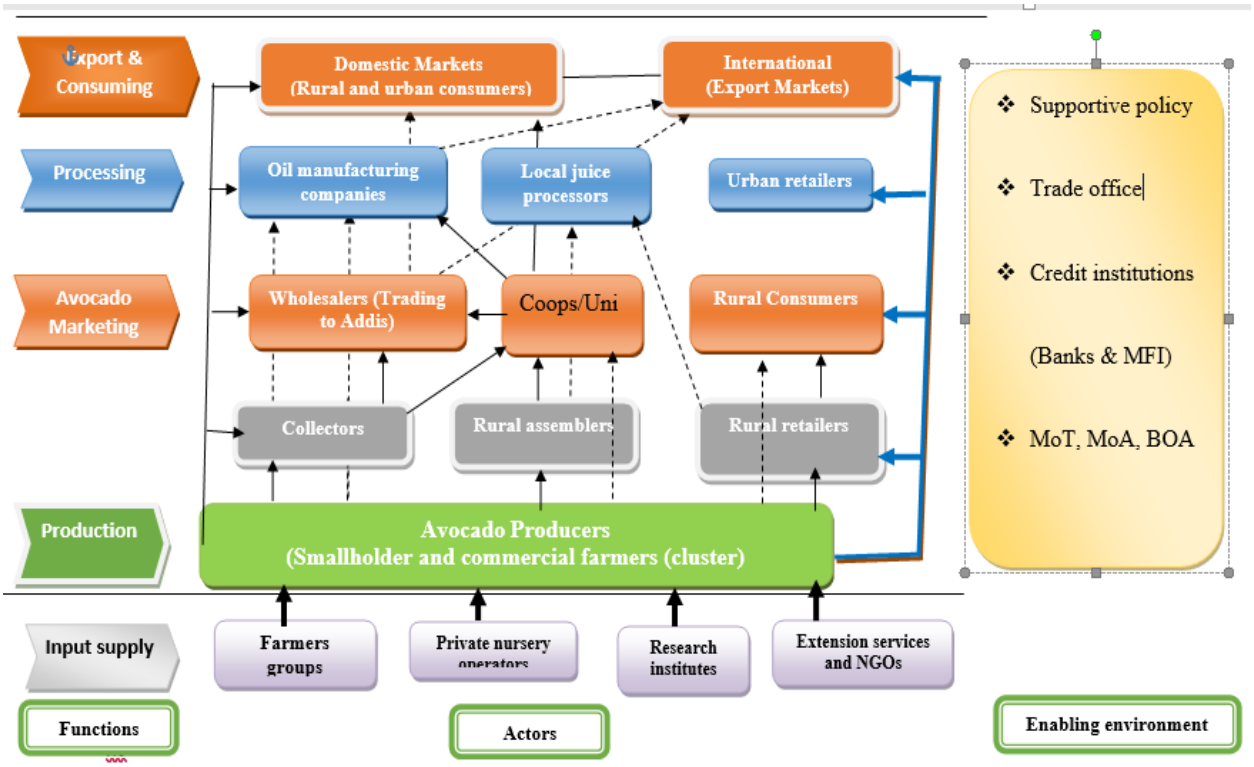

Figure 3.6. 7: Avocado value chain map in the study areas

3.6.14. Marketing constraints in the avocado value chain

The critical constraints affecting the avocado market and its actors included the low market price of avocados, insufficient linkages between producers and consumers, the perishable nature of the product, poor information flow, quality challenges, inadequate infrastructure, and problems related to transportation and packaging. A higher respondent frequency was observed in reports concerning the low market price of avocados and insufficient market linkage (Table 3.6.9).

Strengthening market linkages is important to support local businesses to deliver products that meet the standards of large firms, and encourage local businesses to invest in new technologies and practices to improve quality and quality. Market linkages enhance the movement of goods and services across various tiers of the marketing systems, thereby fostering competitiveness and job creation while promoting economic growth.

In the context of smallholder farming, market linkages can be improved through: (1) establishing collective action organizations that enable smallholders to attract larger buyers, access expanded markets, negotiate more favorable prices, and minimize transaction costs, thereby enhancing economies of scale; 2) utilizing contract farming arrangements that secure market access and fair pricing by removing non-value-adding intermediaries; and 3) promoting smallholder certification, which allows farmers to benefit from stable, premium prices in more reliable markets, regardless of fluctuations in local market conditions.

Table 3.6. 9: Major avocado marketing constraints in the study areas

Constraint	Respondent Frequency	Percent	Rank
Low market price of avocado	246	91.8	1
Distant to avocado markets	188	70.1	5
lack of access to market information	156	58.2	7
Quality problem	194	72.4	4
Lack of packing and transportation facilities	181	67.5	6
Poor market linkage	239	89.2	2
Traditional weight measures	110	41.0	9
Perishability and seasonal maturity of avocado	181	87.5	3
Poor infrastructure	151	57.0	8

3.6.15. Avocado wholesale and retail markets

The fresh fruit and vegetable wholesale segment is very influential in the horticulture industry of Ethiopia. This segment generally operates in a closed and frequently opaque manner, benefiting a limited number of actors across different levels and regions. Wholesalers lead the distribution of fruits and vegetables to different market destinations. They monopolistically control market information and pricing throughout the value chain, influencing producers, brokers, transporters, and retailers. Moreover, wholesalers often resist regulatory measures intended to address their operations and monopoly.

The wholesalers exert control over the entire value chain, thereby capturing a larger chunk of the profit margin. The wholesalers take advantage of the high perishability nature of the fruits and vegetable commodities. Since the wholesalers are experienced in marketing bulk volume of these highly perishable commodities and they have leverage in controlling market information and market actors, their inaction can bring an immediate and catastrophic impact on the marketing of these commodities.

Wholesalers operating in Addis Ababa set prices at the farm gate across all production regions and across the value chain, exerting significant control over their agents who serve as brokers. While they have effectively managed the wholesale of fruits and vegetables and have profited considerably from this sector, their investments in innovations that could reduce losses and improve quality and safety are quite limited. For these wholesalers, the potential investment in innovations that lessen perishability is viewed as a threat to their control and profit. The lack of investment in innovation among wholesalers may be linked to the educational attainment of the market's business owners and operators, as surveys indicate that a predominant number have education levels that do not exceed grade 10. Similarly, those engaged in the retail marketing of avocados are largely educated only at the high school level.

Besides Addis Ababa, wholesalers were also found operating in the traditionally significant avocado-growing regions of Jimma, Sidama, Kaffa, and Wolaita zones. The wholesale avocado trade is primarily male-dominated, with women mainly involved in retail activities. The highest level of experience among avocado traders in this industry is limited to about seven years.

The study indicated that fresh avocado fruits reach the wholesalers' warehouses located in central markets of Addis Ababa, including Jemmo, Karra, and Kolfe, early in the morning (Figure 3.6.8). Wholesalers indicate that they promptly begin distributing these fruits to retailers

or sorting them into three classes: first class for supermarkets in Addis Ababa, second class for Adama, and third class for other towns across Ethiopia.

Figure 3.6. 8: Avocado fruits wholesalers at Jemmo (Garment), Addis Ababa

3.6.16. Traders' avocado variety preference

The study on buyer varietal preferences revealed that purchasing decisions are primarily influenced by supply factors. Consequently, most traders do not exhibit a strong preference for specific avocado varieties, opting instead to trade fruits sourced from traditionally cultivated orchards located in the southwestern region of the country. A newly established clonal orchard, supported by government initiatives, is facilitating the scaling of the Hass variety across various regions. Many traders have shown a preference for this variety due to its superior keeping quality and favorable market reception. Additionally, the export market has a distinct inclination towards the Hass variety. However, the absence of standardized grading in avocado marketing is hindering the overall development and performance of the avocado value chain. In response to the demands of the export market, government efforts in avocado development are primarily aimed at promoting the Hass variety, which poses significant risks in both production and market dynamics.

3.6.17. Avocado fruit grades at wholesalers' and traders' level

The survey revealed the presence of various grades of avocado fruit across different cultivation regions. Among wholesalers and retailers, the majority, 56.3%, believe that there are three distinct grades. In contrast, 25% of these stakeholders perceive that there are either no grades or only a single grade of avocado fruit, while 18.8% assert that there are two grades (Table 3.6.10).

Table 3.6. 10: Number of avocado fruit grades in different zones

Region	Zone	Number of grades known in the market (%)		
		One	Two	Three
Oromia	East Shewa	50	0	50
	Jimma	50	50	0
	Average	**50**	**25**	**25**
Amhara	North Gojjam	33.3	0	66.7
Sidama	Central Sidama	0	0	100
	Northern Sidama	0	0	100
	Average	**0**	**0**	**100**
South West Ethiopia	Kaffa	100	0	0
Central Ethiopia	Silte	0	50	50
South Ethiopia	Wolaita	0	50	50
Total		**25**	**18.8**	**56.3**

Source: Computed from Survey Data, 2024

3.6.18. Purchasing price of avocado fruits

The demand for avocado fruits is on the rise in regions where they have traditionally been utilized, such as the Sidama and Wolaita areas. Additionally, the incorporation of avocados into non-traditional food systems is also increasing. The use of avocados for oil extraction has further contributed to this growing demand. Moreover, the introduction of the Hass variety has significantly boosted avocado consumption throughout Ethiopia. Furthermore, the export of Hass avocados has created a competitive market, allowing farmers to achieve higher prices.

The prices at which wholesalers and retailers purchase avocados in various avocado-producing regions of Ethiopia are detailed in Table 3.6.11. As discussed earlier, the Hass variety is particularly sought after for its longer shelf life and superior taste, while avocados derived from local varieties are characterized by their thin skin, which is vulnerable to damage, and their highly variable taste and flavor profiles.

Table 3.6. 11: Purchasing price of avocado by wholesalers and retailers

Region	Zone	Purchasing price (Birr/100 kg)		
		Mean	Min	Max
Oromia	East Shewa	2200	1650	2750
	Jimma	1010.25	753	1267.5
	Average	1605.13	1201.5	2008.75
Amhara	North Gojjam	3437.5	2851.67	4023.33
Sidama	Central Sidama	2050	1350	2750
	Northern Sidama	1850	1500	2200
	Average	1950	1425	2475
South West Ethiopia	Kaffa	1500	1000	2000
Central Ethiopia	Silte	1756.25	1502.5	2010
South Ethiopia	Wolaita	963.25	909	1017.5
Overall		1845.9	1439.5	2252.3

Source: Computed from Survey Data, 2024

Survey results revealed that the prices for Grade I Hass avocados from East Shewa, North Gojjam, and Silte areas are notably high, at 3250 Birr, 6833 Birr, and 7000 Birr per quintal, respectively (Table 3.6.12).

Table 3.6. 12: Price for different grades of avocado at wholesalers' and retailers level

Region	Zone	Avocado price for various grades (Birr/100 Kg)		
		Grade 1	Grade 2	Grade 3
		Mean	Mean	Mean
Oromia	East Shewa	3250	1000	750
	Jimma	1850	1500	--
	Average	**2550**	**1250**	**750**
Amhara	North Gojjam	6833	6333	5500
Sidama	Central Sidama	2500	1750	1100
	N. Sidama	2700	2000	1100
	Average	**3281**	**2306**	**1840**
SW Ethiopia	Kaffa	0	0	0
Central Ethiopia	Silte	7000	4250	750
South Ethiopia	Wolaita	3750	2750	18
Total		**3913**	**2933**	**1535**

Source: Computed from Survey Data, 2024

3.6.19. Avocado fruit standard/ quality measures of wholesalers and retailers

The local grading of avocado fruits is thought to be based on various attributes such as color, firmness, size, variety, and skin defects. According to the study, avocado wholesalers and retailers apply these criteria when purchasing fresh avocados. The results demonstrated that 93.8% of the surveyed wholesalers and retailers grade avocados primarily by size, with 68.85% focusing on defects in the skin. Furthermore, 62.5% grade by color, while 56.3% consider both firmness and variety in their grading assessments (Table 3.6.13).

Table 3.6. 13: Avocado fruit standard/ quality measures in different zones

Region	Zone	Quality measure (%)					
		Color	Firmness	Size	Variety	Defects	Others
	E. Shewa	0.0	0.0	100.0	50.0	0.0	0.0
Oromia	Jimma	100.0	100.0	100.0	100.0	100.0	50.0
	Average	50.0	50.0	100.0	75.0	50.0	25.0
Amhara	N Gojjam	66.7	100.0	100.0	100.0	100.0	0.0
	C. Sidama	50.0	0.0	100.0	0.0	0.0	50.0
Sidama	N. Sidama	100.0	0.0	100.0	50.0	100.0	0.0
	Average	75.0	0.0	100.0	25.0	50.0	25.0
S Ethiopia	Kaffa	100.0	100.0	100.0	0.0	100.0	0.0
C Ethiopia	Silte	0.0	50.0	50.0	0.0	50.0	0.0
S Ethiopia	Wolaita	100.0	100.0	100.0	100.0	100.0	100.0
Mean		62.5	56.3	93.8	56.3	68.8	25.0

Source: Computed from Survey Data, 2024

3.6.20. Influence of actors in avocado price determination

The study conducted on the factors influencing avocado pricing across various regions revealed that 75.0% of participants indicated that wholesalers play a key role in setting the price. In contrast, 18.8% attributed the pricing to growers, while 12.6% of wholesalers and retailers believed that middlemen are determining the price (Table 3.6.14). There is, as of now, no institution or government sector dedicated to supporting avocado development through price negotiations. This situation leaves avocado growers in a position where they are merely price takers. Moreover, there is an absence of value addition in the packaging of avocados at every level of the supply chain in Ethiopia.

Table 3.6. 14: Actors who determine the avocado price (wholesalers and retailers)

Region	Zone	Who determine the price (%)			
		Middlemen	Wholesaler	Growers	Others
	East Shewa	50	100	0	0
Oromia	Jimma	0	100	0	50
	Average	**25**	**100**	**0**	**25**
Amhara	North Gojjam	0	100	66.7	0
	Central Sidama	0	50	0	50
Sidama	N. Sidama	50	50	0	50
	Average	**25**	**50**	**0**	**50**
SW Ethiopia	Kaffa	0	100	0	0
C. Ethiopia	Silte	0	0	0	100
South Ethiopia	Wolaita	0	100	50	50
Mean		**12.5**	**75**	**18.8**	**37.5**

Source: Computed from Survey Data, 2024

3.6.21. Avocado selling prices of wholesalers and retailers

The survey evaluated the market prices of avocado fruits across all sampled regions. It was found that avocado prices differ significantly by variety; the Hass variety commands a high price, while the local variety is considerably more affordable. The findings indicated that in the East Shewa, North Gojjam, and Site Zones, avocado prices are notably high, reaching 3500 Birr, 6083 Birr, and 7000 Birr per quintal, respectively. In contrast, the prices in Jimma and Kaffa are lower, at 3200 Birr and 2100 Birr per quintal, where the avocados are sourced from local varieties (Table 3.6.15).

Table 3.6. 15: Avocado selling price by wholesalers and retailers

Region	Zone	Selling price per 100 kg		
		Mean	Min	Max
	East Shewa	3500	3000	4000
Oromia	Jimma	3200	2400	4000
	Average	3350	2700	4000
Amhara	North Gojjam	6083.3	5333.3	6833.3
	Central Sidama	1175	1000	1350
Sidama	Northern Sidama	2050	1450	2650
	Average	1612.5	1225	2000
S West Ethiopia	Kaffa	2100	2000	2200
Central Ethiopia	Silte	7000	6000	8000
South Ethiopia	Wolaita	4050	3600	4500
Mean		3893.8	3306.3	4481.3

Source: Computed from Survey Data, 2024

An examination of access to advance payments for avocado by purchasers indicates that 56.3% of wholesalers and retailers are able to secure immediate payment. On the other hand, 48% of traders do not receive their payments right away, but rather after a delay, as detailed in Table 3.6.16.

Table 3.6. 16: Access to advance payment of the avocado fruit producers

Region	Zone	Access to advance payment (%)	
		No	Yes
	East Shewa	100	0
Oromia	Jimma	0	100
	Average		
Amhara	North Gojjam	100	0
	Central Sidama	50	50
Sidama	Northern Sidama	0	100
	Average		
South West Ethiopia	Kaffa	100	0
Central Ethiopia	Silte	0	100
South Ethiopia	Wolaita	0	100
Mean		**43.8**	**56.3**

3.6.22. Communication channels of traders to access information

The investigation into the communication methods employed by traders for information access demonstrated that avocado traders rely on television, SMS messages from friends and fellow traders, and direct communication among themselves. As a result, 88.8% of wholesalers and retailers communicate through other traders, with 44.4% of wholesalers and traders utilizing their friends as a means of information exchange (Table 3.6.17).

Table 3.6. 17: Proportion of traders using different communication channels

Region	Zone	Information channel (%)				
		Radio / Tv	SMS	Friends	Traders	Others
Oromia	Jimma	0	0	50	100	100
	C. Sidama	0	0	100	100	0
Sidama	N. Sidama	0	0	50	50	50
	Average	0	0	66.7	83.3	50
C Ethiopia	Silte	0	0	0	100	50
S Ethiopia	Wolaita	0	0	50	100	100
Mean		0	0	44.4	88.9	66.7

Source: Computed from Survey Data, 2024

3.6.23. Repackaging and storage of avocado fruits by traders

The survey investigated whether wholesalers and retailers engage in repacking avocado fruits. The findings revealed that 56.3% of wholesalers and retailers do not participate in repacking, while 43.8% do engage in the repacking of fresh avocado fruits (Table 3.6.18).

Table 3.6. 18: Practice in repacking the fruit before storage (wholesalers and retailers)

Region	Zone	Practice of repackaging before storage (%)	
		No	Yes
Oromia	East Shewa	50	50
	Jimma	100	0
	Average	75	25
Amhara	North Gojjam	0	100
Sidama	Central Sidama	50	50
	Northern Sidama	50	50
	Average	50	50
South West Ethiopia	Kaffa	100	0
Central Ethiopia	Silte	100	0
South Ethiopia	Wolaita	50	50
Mean		56.3	43.8

Source: Computed from Survey Data, 2024

An investigation into the avocado storage practices of traders in different avocado-producing regions indicated that 25% of wholesalers and retailers utilize simple shade houses for bulk storage. Additionally, 18.8% store fresh avocados in brick houses with cement flooring, while another 18.8% opt for simple shade houses using wooden crates. A minor segment, comprising 6.3%, employs cold storage facilities with plastic crates (Table 3.6.19). Overall, the various storage facilities are significantly underdeveloped and lack controlled atmosphere systems, highlighting a substantial investment gap. Therefore, it is essential to develop suitable storage facilities for wholesalers and retailers, accompanied by capacity-building initiatives for these stakeholders. Additionally, there is a complete absence of value addition in avocado packaging throughout all levels of the supply chain in Ethiopia.

Table 3.6. 19: Storage facility used by the traders

Region	Zone	Storage mechanism					
		Cold storage in plastic crates	Inside a simple shade house in Wooden	Inside bricks house on a cement floor	Inside a simple shade house in bulk	Inside a brick concrete house on cement floor	Others
Oromia	E Shewa	50	0	50	0	0	0
	Jimma	0	0	0	50	50	0
	Average	25	0	25	25	25	0
Amhara	North Gojjam	0	100	0	66.7	0	0
Sidama	Central Sidama	0	0	0	50	0	50
	Northern Sidama	0	0	50	0	0	50
	Average	0	0	25	25	0	50
South West Ethiopia	Kaffa	0	0	0	0	0	100
Central Ethiopia	Silte	0	0	0	0	0	100
South Ethiopia	Wolaita	0	0	50	0	0	50
Mean		**6.3**	**18.8**	**18.8**	**25**	**6.3**	**37.5**

Source: Computed from Survey Data, 2024

3.6.24. Use of low-quality avocado fruits by traders (wholesalers and retailers)

Avocado fruits of inferior quality are utilized for a range of purposes throughout different stages of the supply chain. The research indicated that 50% of traders discard low-quality avocado fruits in proximity to the marketplace, while 31.3% opt to sell these fruits separately at a lower price. Furthermore, an equal percentage of 31.3% of traders indicated that they repurpose low-quality avocado fruits for various uses (Table 3.6.20). The study indicated a lack of food safety regulation, thereby increasing the risk of consumers being exposed to foodborne illnesses.

The findings of this study reveal an absence of food safety regulation, which poses a significant risk of exposing consumers to foodborne diseases.

Table 3.6. 20: Use of low-quality avocado fruits by the traders

Region	Zone	Use of low-quality avocado fruits by traders (%)				
		Throw them away near the marketplace	Sell them separately at a reduced price	Provide them to animals as feed	Redirect them to waste collectors	Others
Oromia	E Shewa	100	0	0	0	0
	Jimma	100	0	0	0	0
	Average	100	0	0	0	0
Amhara	N Gojjam	66.7	100	33.3	0	0
Sidama	C Sidama	50	50	0	0	0
	N Sidama	0	50	0	0	50
	Average	25	50	0	0	25
S W Ethiopia	Kaffa	0	0	0	0	100
C Ethiopia	Silte	50	0	0	0	50
South Ethiopia	Wolaita	0	0	0	0	100
Mean		50	31.3	6.3	0	31.3

Source: Computed from Survey Data, 2024

3.6.25. Distance to central marketplace

Avocado traders procure fresh avocado fruits by traversing varying distances from the source of production to their respective marketing locations, catering to both wholesalers and retailers across different regions of Ethiopia known for avocado cultivation. The study revealed that the distance traveled is influenced by the proximity of the city or town to the production area. For instance, East Shewa is located 100 kilometers from Addis Ababa, while the Jimma region is approximately 380 kilometers away from the capital (Table 3.6.21). The distance from the production site to Addis Ababa is determined by the location from which all traders transport their fresh avocado fruits. Should a trader travel from Jimma or Wolaita to Dessie or another destination, the distance will consequently increase.

Table 3.6. 21: Distance from the avocado source to the traders marketing place

Region	Zone	Distance from the source to traders' market place (km)			
		Mean	Std Dev	Minimum	Maximum
Oromia	East Shewa	100.1	141.4	0.1	200
	Jimma	380	28.3	360	400
	Average	240	84.8	180.1	300
Amhara	North Gojjam	14.3	15.3	5	32
Sidama	C. Sidama	8.5	2.1	7	10
	N. Sidama	22.5	24.7	5	40
	Average	15.5	13.4	6	25
SW Ethiopia	Kaffa	--	--	--	--
C Ethiopia	Silte	1.3	1.1	0.5	2
South Ethiopia	Wolaita	180	254.6	0	360
Mean		**89.2**	**149.4**	**0**	**400**

Source: Computed from Survey Data, 2024

3.6.26. Transaction costs of avocado marketing by traders

An analysis was performed to determine the marketing costs associated with avocados per 100 kg, which included transportation and additional operational expenditures in the sampled regions. The results demonstrated that the price for the Hass variety is considerably high, recorded at 2,300 Birr in East Shewa and 9,400 Birr in North Gojjam (Table 3.6.22). In contrast, the costs for local avocado varieties in the Jimma, Wolaita, and Kaffa Zones were found to be lower.

Table 3.6. 22: Transaction costs of avocado marketing by traders

Region	Zone	Cost of avocado marketing per 100 kg including transportation and other operating costs		
		Mean	Minimum	Maximum
Oromia	East Shewa	2300	2300	2300
	Jimma	19	19	19
	Average	1160	1160	1160
Amhara	North Gojjam	9400	200	20000
	Central Sidama	165	30	300
Sidama	N. Sidama	2250	2250	2250
	Average	1208	1140	1275
SW Ethiopia	Kaffa			
Central Ethiopia	Silte			
South Ethiopia	Wolaita	1300	600	2000
Total		**3570**	**19**	**20000**

Source: Computed from Survey Data, 2024

Furthermore, an investigation was carried out to evaluate the costs associated only with transporting avocado fruits from local markets to central locations by wholesalers and retailers in different avocado-producing regions of Ethiopia. The results demonstrated that the transportation expenses for avocados from the Kaffa region are considerably higher, averaging 400 birr per 100 kg. In contrast, transporters from Jimma charge an average of 342 birr for the transportation of 100 kg of avocados (Table 3.6.23).

Table 3.6. 23: The cost of transportation by wholesalers and retailers

Region	Zone	Cost of transportation (Birr per 100 kg)		
		Mean	Minimum	Maximum
Oromia	East Shewa	142.5	115	170
	Jimma	342.4	316.8	368
	Average	242.45	215.9	269
Amhara	North Gojjam	341.65	233.3	450
Sidama	Central Sidama	25	20	30
	Northern Sidama	172.5	165	180
	Average	98.75	92.5	105
South West Ethiopia	Kaffa	400	400	400
Central Ethiopia	Silte	18.75	12.5	25
South Ethiopia	Wolaita	-	3	4
	Mean		**147.8**	**206**

Source: Computed from Survey Data, 2024

3.7. Avocado Harvest and Postharvest Loss Determination

3.7.1. Avocado postharvest loss desk review findings

In the process of reviewing available documents on the avocado postharvest loss assessment, several gaps have been identified. In Ethiopia, there is a notable lack of focus on the assessment of post-harvest losses. The data available on these losses is often inconsistent, primarily due to the application of non-standardized methodologies for post-harvest loss assessment. Furthermore, a significant portion of the studies rely on self-reported data and controlled laboratory experiments.

The lack of adequate experience and skills in the evaluation and reporting of postharvest losses (PHL) has resulted in data that is not disaggregated into qualitative and quantitative, often leading to aggregated reporting. There is also a significant gap in studies that investigate postharvest losses in the entire value chain. Only a handful of PHL studies trace a specific crop from the harvest stage through the food supply chain, measuring losses at various points, which makes it challenging to calculate total PHLs for the entire food supply chain. Moreover, there is a dearth of PHL studies that present data at critical loss points.

Furthermore, the underlying causes and factors that lead to postharvest losses are often insufficiently detailed. The impacts of PHL are not also comprehensively described. Reporting

on PHL should extend beyond mere percentages or volumes of food lost, but also in terms of monetary value, food and nutrition security, environmental impact, the volume of raw materials that failed to fuel up industrialization, and the country's development agenda.

This study attempted to estimate avocado fruit losses in the avocado harvest and post-harvest supply chain through two approaches: (1) conducting surveys and collecting self-reported data from a sample of respondents, and (2) Direct measurement of avocado losses and the identification of critical loss points using a load-tracking technique. Additionally, the research assessed the nutritional, economic, and environmental ramifications of these losses within the avocado supply chain. This section details the findings regarding post-harvest losses of avocado fruit, using both the subjective and objective methods.

3.7.2. Avocado Harvest and Postharvest Loss Estimation – A Survey Method

The study attempted to estimate avocado fruit losses during the harvest and post-harvest stages of the supply chain. It utilized surveys to gather data, relying on self-reported estimates from selected respondents. The results are presented as below.

3.7.2.1 Quantitative loss of avocado fruits during harvesting

Avocado fruit is inherently highly perishable owing to its high-water content, and other anatomical and morphological features. Consequently, avocado requires high care during harvesting, transportation; storage, postharvest handling, and the whole supply chain until it reaches consumers (Figure 3.7.1). Any mismanagement at any point across the supply chain can result in substantial losses. Further, avocado fruit is highly susceptible to postharvest diseases like anthracnose, dothiorella fruit rot, and avocado stem end rot, which account for a considerable portion of these additional losses (Hofman *et al*., 2012; Dann *et al*., 2012).

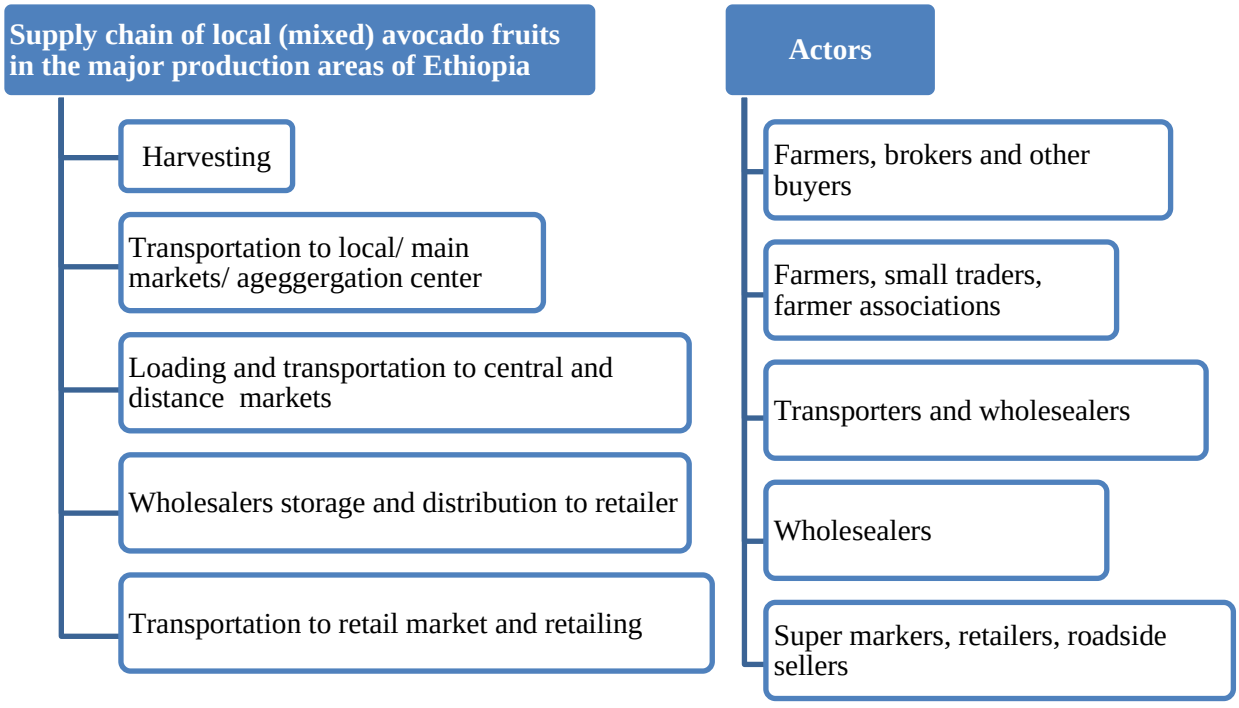

Figure 3.7. 1: Avocado fruits domestic markets supply chain and major actors

This study revealed that approximately 5% of fruits are lost at the smallholder level due to inappropriate harvesting practices. Avocado fruit loss varies depending on the type of avocado. Grafted avocado trees experience minimal loss during harvesting, as their dwarf size simplifies the harvesting procedure. Accordingly, the estimated loss from grafted Hass avocado trees in the East Shewa and Silte zones is 2%, while in North Gojjam, the loss is recorded at 6.4%. In contrast, local ungrafted avocado trees in the Jimma and Kaffa zones experience losses of 6% and 8%, respectively (Table 3.7.1). Abera (2022) indicated that a loss of 5.7% of avocados occurred during the harvesting processes in the Wolaita and Kembata-Tembaro Zones of Ethiopia.

The losses occurring in avocado fruits can generally be attributed to inadequate agronomic management, which leads to the production of undersized and shriveled fruits, physiological disorders, pest infestations, nutrient deficiencies, and fruits that are unfit for the market (Table 3.7.1). During harvesting, the maturity level at the time of harvesting and the harvesting methods applied are pivotal factors that determine the extent of losses experienced by avocado fruits.

Table 3.7. 1: Avocado quantity loss at the harvesting stage

Region	Zone	Loss at harvesting in kg (per/100 kg)			
		Mean	SD	Minimum	Maximum
Amhara	North Gojjam	5.0	4	1.0	20.0
Central Ethiopia	Silte Zone	2.0	3	0.0	10.0
	East Shewa	2.0	3	0.0	10.0
Oromia	Jimma	6.0	4	0.0	20.0
	Average	5.0	4	0.0	20.0
	Central Sidama	4.0	2	0.0	10.0
Sidama	Northern Sidama	4.0	3	0.0	10.0
	Average	4.0	2	0.0	10.0
South Ethiopia	Wolaita	4.0	4	0.0	20.0
S. West Ethiopia	Kaffa	8.0	5	2.0	20.0
Mean		5.0	4	0.0	20.0

Source: Computed from Survey Data, 2024

The study further assessed that the average loss in fruit quality at the time of harvesting is approximately 2.6% of the total harvest across the regions examined, as shown in Table 3.7.2. According to Bill *et al.* (2014), the significant contributors to the decline in postharvest quality of avocados along the marketing chain are primarily mechanical injuries incurred during harvesting and transportation. Other factors include overripe and desiccated fruit, postharvest diseases like anthracnose and stem-end rots, and chilling injuries caused by improper storage temperatures. Furthermore, pest damage and physiological disorders also contribute to these quality losses. These issues negatively influence the fruit's appearance, texture, taste, and nutritional value. Specifically, loss of firmness and chilling injury are identified as major

limitations affecting the retail quality of avocados subjected to variable temperatures during shipping and handling simulations (Pesis *et al*., 1978).

In summary, when considering both quantitative and qualitative losses, it is estimated that small-scale avocado growers experience an overall loss of 7.6% during the harvesting process.

Table 3.7. 2: Avocado quality loss at the harvesting stage

		Quality loss in kg (per/100kg)			
Region	Zone	Mean	Std. Deviation	Minimum	Maximum
Amhara	North Gojjam	9.2	10.3	2.0	50.0
Central Ethiopia	Silte Zone	1.7	2.4	0.0	10.0
Oromia	East Shewa	1.2	2.2	0.0	10.0
	Jimma	2.1	1.3	0.0	5.0
	Average	1.8	1.7	0.0	10.0
Sidama	C. Sidama	1.7	1.3	0.0	5.0
	N. Sidama	1.7	2.1	0.0	10.0
	Average	1.7	1.7	0.0	10.0
South Ethiopia	Wolaita	0.9	1.1	0.0	5.0
S. West Ethiopia	Kaffa	1.9	1.0	0.0	5.0
Mean		2.6	4.6	0.0	50.0

3.7.2.2 Quantitative loss of avocado fruits during storage by the farmers

The study indicated that approximately 2% of avocado fruits are lost during the storage period, attributed to various factors, including damage caused by rodents (Table 3.7.3).

Table 3.7. 3: Avocado storage loss at producers' level

		Storage loss kg/per 100Kg			
Region	Zone	Mean	Std. Deviation	Minimum	Maximum
Amhara	North Gojjam	3	3	1	20
Central Ethiopia	Silte Zone	2	3	0	20
Oromia	East Shewa	2	3	0	20
	Jimma	1	2	0	10
	Total	1	3	0	20
Sidama	Central Sidama	1	1	0	5
	Northern Sidama	2	3	0	10
	Total	1	2	0	10
South Ethiopia	Wolaita	1	3	0	20
	Total	1	3	0	20
South West Ethiopia	Kaffa	2	4	0	15
Mean		2	3	0	20

Source: Computed from Survey Data, 2024

3.7.2.3. Quantitative loss of avocado fruits during transportation to the local market

Avocado fruits are poorly handled during transportation to the local market. The survey revealed that around 1% of these fruits are lost while being transported to the local and primary Woreda markets (Table 3.7.4).

Table 3.7. 4: Loss of avocado fruits during transportation to the local market

		Transport loss to local market in Kg (Kg/100kg			
Region	Zone	Mean	St. Deviation	Minimum	Maximum
Amhara	North Gojjam	3	3	0	10
Central Ethiopia	Silte Zone	0	1	0	5
Oromia	East Shewa	0	0	0	2
	Jimma	0	0	0	0
	Total	0	0	0	2
Sidama	Central Sidama	0	0	0	2
	Northern Sidama	0	0	0	1
	Total	0	0	0	2
South Ethiopia	Wolaita	0	0	0	2
South West Ethiopia	Kaffa	0	1	0	7
Mean		1	2	0	10

Source: Computed from Survey Data, 2024

3.7.2.4. Loss of avocado fruits as low-quality during sorting by the farmers

According to the survey study, an average of 1.81% of fruits is lost as a result of being classified as low quality during the marketing process (Table 3.7.5). Farmers typically discard or sort out fruits that are undersized, immature, or physically damaged. Fruits classified as low quality are those that remain after the sorting and grading process and are deemed unsellable in the market. High-quality fruits are packaged and transported to the market, while the rejected fruits are set aside. However, some family members may sift through these rejected fruits to salvage those with minimal damage for personal consumption.

Table 3.7. 5: Avocado fruit quality loss due to marketing process

Region	Zone	Low quality loss during marketing (%)			
		Mean	Std. Deviation	Minimum	Maximum
Amhara	North Gojjam	2.0	13.2	1.0	75.0
Central Ethiopia	Silte Zone	1.9	1.7	0.0	5.0
	East Shewa	1.5	3.0	0.0	20.0
Oromia	Jimma	1.2	1.4	0.0	8.0
	Total	1.3	2.1	0.0	20.0
	C. Sidama	2.1	1.3	0.0	5.0
Sidama	N. Sidama	2.5	2.7	0.0	10.0
	Total	2.3	2.1	0.0	10.0
South Ethiopia	Wolaita	1.8	1.4	0.0	5.0
	Total	1.8	1.4	0.0	5.0
SW Ethiopia	Kaffa	1.5	1.6	0.0	5.0
Mean		1.81	5.6	0.0	75.0

Source: Computed from Survey Data, 2024

3.7.2.5. Quality loss encountered by the farmers at the marketplace

A certain quantity of avocado fruits is discarded due to substandard quality during the sorting process in local markets, leading to their rejection by traders. According to the survey, it is estimated that around 2.15% of avocado fruits are lost as a consequence of low quality in local markets (Table 3.7.6).

Table 3.7. 6: Quality loss encountered by the farmers at the local market place

Region	Zone	Low-quality loss at the marketplace			
		Mean	Std. Dev	Min	Max
Amhara	North Gojjam	2.0	13.2	1.0	75.0
Central Ethiopia	Silte Zone	1.9	1.7	0.0	5.0
	East Shewa	1.5	3.0	0.0	20.0
Oromia	Jimma	1.2	1.4	0.0	8.0
	Total	1.3	2.1	0.0	20.0
	Central Sidama	2.1	1.3	0.0	5.0
Sidama	Northern Sidama	2.5	2.7	0.0	10.0
	Total	2.3	2.1	0.0	10.0
South Ethiopia	Wolaita	1.8	1.4	0.0	5.0
	Total	1.8	1.4	0.0	5.0
South West Ethiopia	Kaffa	1.5	1.6	0.0	5.0
Mean		2.15	5.6	0.0	75.0

Source: Computed from Survey Data, 2024

3.7.2.5.1 Use of poor-quality avocado fruits by smallholder growers

The study found that the highest, 64.5% of respondents reported that poor quality avocado fruits are used for animal feed, followed by 57.5% of the respondents stated that they use such fruits for home consumption, while 12.5% of the farmers stated that they sell poor quality fruits with lower price.

Unmarketable avocado fruits are typically not discarded; instead, they are repurposed for several uses, including animal feed, sold at reduced prices, consumed by families, or utilized in composting. According to the findings of the study, a significant 64.5% of respondents indicated that they use poor-quality avocado fruits for animal feed. Furthermore, 57.5% of the respondents reported that they consume such fruits within their households, and 12.5% of farmers acknowledged selling these inferior fruits at a lower price (Figure 3.7.2).

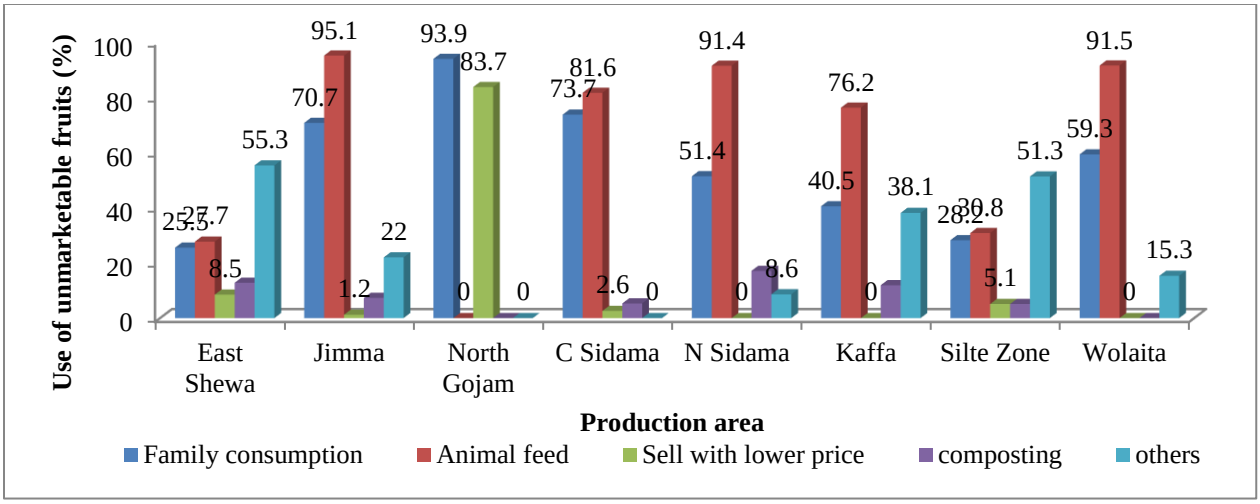

Figure 3.7. 2: Use of unmarketable avocado fruits (rejects) by the smallholder producers

The study findings revealed that, on average, there is a discount of 1 Birr on low-quality avocado fruits across various study zones (Table 3.7.7). A discount of 1 Birr per kilogram is applicable in production areas where avocado fruits are available and offered at a reduced price.

Table 3.7. 7: Average discount price of low-quality fruits in different areas

Region	Zone	Discount price of low-quality fruits (Birr/kg)			
		Mean	Std. Dev	Minimum	Maximum
	East Shewa	1	4	0	20
Oromia	Jimma	0	0	0	2
	Average	1	2	0	11
Amhara	North Gojjam	13	8	1	50
	C Sidama	1	3	0	10
Sidama	N Sidama	1	2	0	10
	Average	1	3	0	10
S W Ethiopia	Kaffa	0	0	0	2
C Ethiopia	Silte Zone	2	4	0	25
S Ethiopia	Wolaita	0	1	0	5
Mean		2	5	0	50

Source: Computed from Survey Data, 2024

3.7.2.6. Quantitative loss of avocados during transportation to the central markets

Large quantities of fresh avocado fruits are lost during the processes of loading, transportation, and unloading, especially from aggregation centers located in production areas to central markets such as Addis Ababa, Adama, Dessie, Mekelle, Dire Dawa, Harar, Jigjiga, and various other cities and towns across Ethiopia. The fruits are stacked together in large quantities without adequate ventilation, temperature regulation, or controlled atmosphere (CA) systems.

The survey indicated that an average loss of 2.4 kg per 100 kg (2.4%) of fresh fruits occurs during the processes of loading, transportation, and unloading from the production area to the market center in Addis Ababa (Table 3.7.8). Nevertheless, it is anticipated that the percentage of loss will rise as the trucks travel to more distant locations, including Mekelle, Harar, Jigjiga, Semera, and other regional cities.

Table 3.7. 8: Loss of avocado fruits due to transportation to the central market

Region	Zone	Estimated loss during transport Kg per 100kg			
		Mean	Stan Dev	Min	Max
Amhara	North Gojjam	1.7	1.2	1.0	3.0
Central Ethiopia	Silte	2.0	0.0	2.0	2.0
Oromia	East Shewa	1.5	0.7	1.0	2.0
	Jimma	3.0	0.0	3.0	3.0
	Total	2.3	1.0	1.0	3.0
Sidama	Central Sidama	3.5	2.1	2.0	5.0
	N. Sidama	2.0	0.0	2.0	2.0
	Total	2.8	1.5	2.0	5.0
South Ethiopia	Wolaita	3.5	2.1	2.0	5.0
South West Ethiopia	Kaffa	2.0		2.0	2.0
	Mean	2.4	1.2	1.0	5.0

Source: Computed from Survey Data, 2024

3.7.2.7. Quality loss of avocado fruits during transportation to the central market

The survey study found the total loss of avocado fruits during unloading, long distance transportation, and unloading quality loss for avocado fruits were assessed, the results found that an estimated 4.5% of the total fruits are lost due to poor quality as indicated in Table 3.7.9.

Table 3.7. 9: Amount of quality loss due to transportation to the central markets

Region	Zone	Volume of quality loss during storage (kg/100kg)			
		Mean	Std Dev	Minimum	Maximum
	East Shewa	11	13	2	20
Oromia	Jimma	3	1	2	3
	Average	7	7	2	12
Amhara	North Gojjam	8	3	5	10
	C. Sidama	6	34	2	50
Sidama	N. Sidama	1	1	0	1
	Average	3.5	10	2	16
SW Ethiopia	Kaffa	0		0	0
C. Ethiopia	Silte	1	1	0	1
South Ethiopia	Wolaita	3	4	0	5
Mean		4.5	13	0	50

Source: Computed from Survey Data, 2024

Observational data indicate the necessity for specific laws and guidelines to ensure the proper management of avocados during transportation. The Ministry of Transport specifies that ISUZU trucks should carry no more than 35,000 kg. However, in the studied regions, these trucks frequently transport loads reaching 60,000 kg. The remuneration for loaders of fruits, including avocados, is determined by the number of quintals they manage to load onto trucks. This system encourages loaders to maximize their output per truck. Unfortunately, the handling practices are often rough, with insufficient oversight allowing loaders to carelessly toss avocados onto the trucks and subsequently offload them by throwing them onto the ground.

Avocados in sacks (Quintals) are dragged into the trucks, resulting in the stacking of produce, which leads to additional damage. The truck beds are not equipped with shock-absorbing materials, and the unprotected sides make direct contact with the avocados, causing abrasion. Furthermore, the uneven and rough roads contribute to constant movement of the fruits, leading to surface bruising on the avocados, which can result in rotting or drying. The findings of the study show that 75% of transporters do not experience penalties for any damage caused to the fruits (Table 3.7.10).

Table 3.7. 10: Penalty faced for damage inflicted during fruits transportation on fruits (%)

Penalty for damage inflicted on fruits	Sex		
	Male	Female	Total
No	75.0	0.0	75.0
Yes	25.0	0.0	25.0
Total	100.0	0.0	100.0

Source: Computed from Survey Data, 2024

The study assessed the perspectives and recommendations of avocado transporters aimed at reducing losses during transportation. The findings revealed that one-third of the transporters, representing 25.0%, emphasized the importance of reducing speed, driving during cooler hours (such as nighttime), and utilizing refrigerated trucks. Another 25% of the transporters highlighted the necessity of minimizing speed, cleaning the vehicle prior to loading, maintaining the road conditions, and employing plastic crates for handling. The final group, also comprising 25% of the transporters, indicated that harvesting methods should prioritize safety, and there should be an emphasis on raising awareness regarding postharvest handling during the transportation of avocados and other perishable fruits and vegetables (Table 3.7.11).

Table 3.7. 11: Transporters' view on minimizing loss of avocados due to transportations (%)

Approaches for minimizing fruits losses	Sex (%)		
	Male	Female	Total
Minimize speed, drive during cold time, using of cold tracks	25.0	0.0	25.0
Minimize speed, wash the care before loading, maintain the road, using plastic creates	25.0	0.0	25.0
Traveling time and harvesting time should be during cooling time Harvesting mechanism should be in safe way Awareness creation on postharvest loss management	25.0	0.0	25.0
Mean	25.0	0.0	25.0

Source: Computed from Survey Data, 2024

3.7.2.8. Quantitative loss of avocados in loading, transporting and unloading at wholesalers

The survey study found the total loss of avocado fruits during unloading, long distance transportation and unloading losses for avocado fruits were assessed, the results found that an estimated 4.5% of the total fruits are lost due to damage and other factors, Table 3.7.12.

Table 3.7. 12: Amount of loss of avocado fruits during loading, and unloading at wholesale

Region	Zone	Volume of loss during loading & unloading (kg/100kg)			
		Mean	Std Dev	Minimum	Maximum
Oromia	East Shewa	11	13	2	20
	Jimma	3	1	2	3
	Average	7	7	2	12
Amhara	North Gojjam	8	3	5	10
Sidama	C. Sidama	6	34	2	50
	N. Sidama	1	1	0	1
	Average	3.5	10	2	16
SW Ethiopia	Kaffa	0		0	0
C. Ethiopia	Silte	1	1	0	1
South Ethiopia	Wolaita	3	4	0	5
Mean		4.5	13	0	50

Source: Computed from Survey Data, 2024

3.7.2.9. Quantitative loss of avocado fruits at storage of wholesalers

The study assessed the total loss of avocado fruit incurred during storage at wholesalers' level. The result indicated that the average loss is estimated to 2.8% (Table 3.7.13). The estimated loss for the East Shewa zone stands at 2%. This loss is primarily linked to the Hass variety of avocado fruits, which are predominantly cultivated for the export market. The rejection of these fruits is due to the stringent standards imposed by the export market. However, these rejected avocados may still be suitable for sale in the local fresh market and for processing facilities.

Table 3.7. 13: Quantity loss at storage of avocado fruits by the wholesalers

Region	Zone	Storage loss of avocado fruit at wholesalers level (kg/100kg)		
		Mean	Minimum	Maximum
Oromia	East Shewa	2	0	20
	Jimma	5	3	7
	Average	3.5	4	14
Amhara	North Gojjam	4	2	7
Sidama	C. Sidama	5	0	50
	N. Sidama	2	0	3
	Average	3.5	0	27
South West Ethiopia	Kaffa	2	0	0
Central Ethiopia	Silte	0	0	0
South Ethiopia	Wolaita	3	0	5
Mean		2.8	0	50

3.7.2.10. Quality loss of avocado fruits at storage level of wholesalers

Beyond the quantitative loss, some avocados lose quality during the storage period at the wholesale level. The study discovered that an average of 4.62% of avocado fruits lose their quality (Table 3.7.14). As a result, traders often sell these inferior quality fruits at discounted prices. Estimated quality loss at wholesaler's storage in kg/100kg

Table 3.7. 14: Quality loss encountered by the wholesalers at storage level

Region	Zone	Estimated quality loss at wholesaler's storage in kg/100kg		
		Mean	Minimum	Maximum
Amhara	North Gojjam	8	5	10
Central Ethiopia	Silte	1	0	1
Oromia	East Shewa	11	2	20
	Jimma	3	2	3
	Total	7	2	20
Sidama	Central Sidama	10	2	50
	Northern Sidama	1	0	1
	Total	13	0	50
South Ethiopia	Wolaita	3	0	5
South West Ethiopia	Kaffa	0	0	0
Total		4.62	0	50

3.7.2.11. Avocado quantitative loss at retail market

Following the purchase of avocado fruits by retailers from wholesalers, some quantity of these fruits is lost within the retail market. The findings from the survey assessment indicate that around 5.5% of the fruits are lost during this time (Table 3.7.15).

Table 3.7. 15: Avocado postharvest loss at retail market (%)

		Estimated loss at retail market kg/100kg			
Region	Zone	Mean	SD	Minimum	Maximum
Amhara	N. Gojjam	5.7	4.0	2.0	10.0
Central Ethiopia	Silte	0.5	0.7	0.0	1.0
Oromia	East Shewa	8.5	10.6	5.0	20.0
	Jimma	3.0	0.0	3.0	3.0
	Average	5.72	8.2	3.0	20.0
Sidama	C. Sidama	5.0	0.0	5.0	5.0
	N. Sidama	6.0	5.7	2.0	10.0
	Average	5.5	3.3	2.0	10.0
South Ethiopia	Wolaita	8.5	9.2	2.0	15.0
South West Ethiopia	Kaffa	0.0		0.0	0.0
	Total	5.5	5.6	0.0	20.0

3.7.2.11.1. Use of the unmarketable avocado fruit

The findings from the interviews conducted to examine the handling of fruits damaged during transportation revealed that 43.8% of respondents discard the affected fruits. Meanwhile, 25% of the respondents indicated that they sell these fruits separately at a lower price. Additionally, another 25% reported that they provide unmarketable avocado fruits as feed for animals; while 6.3% stated that they dispose of the fruits as waste (Table 3.7.16).

Table 3.7. 16: Use of the unmarketable avocado fruit

Region	Zone	Uses of unmarketable fruits (%)				
		Throw away near the market place	Sell with a reduced price	Provide to animals	Redirect to waste collectors	Others
Oromia	East Shewa	50	0	0	50	0
	Jimma	100	0	100	0	0
	Average	**75**	**0**	**50**	**25**	**0**
Amhara	North Gojjam	100	66.7	0	0	0
Sidama	C. Sidama	0	50	0	0	50
	N Sidama	0	0	50	0	50
	Average	**0**	**25**	**25**	**0**	**50**
SW Ethiopia	Kaffa	0	0	0	0	100
C Ethiopia	Silte	50	0	0	0	100
S Ethiopia	Wolaita	0	50	50	0	100
Mean		**43.8**	**25**	**25**	**6.3**	**43.8**

3.7.2.12. Summary of avocado fruit postharvest losses through a survey method

The total estimated loss is 39%, comprising a quantity loss of 23.46% and a quality loss of 15.54% (Table 3.7.17). Consequently, 61% of the total production of fresh avocado fruits successfully flows from producers to end consumers within the avocado supply chain. Abera (2022) reported comparable findings, noting a quantity loss of 5.72% at the harvesting stage, along with an additional 4.09% loss during the unloading and long-distance transportation of avocado fruits. Furthermore, he identified a total quantitative loss of 24.01% in the Wolaita and Kembata-Tembaro Zones of Central Ethiopia. A map of the avocado supply chain, including the identified causes of quality and quantity losses, along with the total postharvest losses from producers to final consumers, are presented in Table 3.7.17.

Table 3.7. 17: Estimated avocado postharvest loss and causes along the supply chain

No	Supply chain stage	Causes	Percent loss (%)	
			Quantity loss	Quality loss
1	Harvesting, temporary storage at farmers home (SC1)	Fruits fall on the ground, damage, maturity problem, timing of harvest not optimal, harvesting immature fruits, stacking together, use of sacks, removal of fruits stalk, over maturity, deformation and other reasons	5.00	2.60
		Storage loss/ stacking together, animal damage after harvest in the producers' home	2.00	1.81
		Transportation to the local markets Bruising, loading and unloading on animal backs, damage created during unloading, throw away from animal backs, motor bike, carts, other transportation	1.00	2.15
		Loss encountered by the farmers at market place during selling	2.4	
2	Loading, transportation and unloading to central and distance markets (SC 2)	Product disregarded /out-grades in supply chain, damage during loading, stacking, transportation, unloading, high temperatures created in the bulk, some ripened and over ripened fruits damage	4.5	
3	Storage of avocado fruits at the wholesaler when the retailers purchase fruits from the wholesalers (SC 3)	Stacking together, use of sacks, removal of fruits stalk, high temperatures in the bulk fasten ripening, some ripened and over ripened fruits damage others	2.8	4.62
5	Transportation to retail market and retailing, retailers-display, marketing, selling, distribution	Inappropriate packaging damages produces; damage during transport; spoilage over ripened fruits; poor handling; losses caused by poor storage, poor storage/ stock management	5.50	4.50
	Total		**23.2**	**15.7**
	Total of total		**38.9**	

To improve the quality of fruits and mitigate the post-harvest (PH) loss of avocados, it is important to identify the various stakeholders involved in the avocado value chain and clarify their respective roles and responsibilities related to PH loss. This information is summarized in Table 3.7.18. Effective management of PH loss involves the collaboration of several responsible entities within the country. Such teamwork is essential for minimizing all forms of loss.

Table 3.7. 18: Gaps associated to key avocado value chain activities and effects

No	Key value chain activity	Gaps	Effects
1	Research	Inadequate diagnosis and lack of management recommendations on pests and diseases, nutrient deficiencies, and physiological disorders contribute to post-harvest loss.	High post-harvest loss associated with pests and diseases, nutrient deficiencies, and disorders
2	Propagation	Dominance of Seedling Seed Orchard with mixed stands; seedling-born pests, extremely tall trees.	Fruits with heterogenous fruit attributes Non-uniform maturity; pests affecting post-harvest qualities, damage during harvesting from taller trees.
3	Extension	Inadequate attention to postharvest handling innovations; In adequate mechanisms to meet standards and grades	High postharvest loss associated with a lack of awareness and poor access to technologies. No or little value addition to improve standards and meet requirements to address food safety issues.
4	Production	Poor orchard management practice: irrigation, soil fertility management, pests and diseases, use of non-uniform seedlings, rarely meets GAP requirements.	Heterogenous and non-uniform fruit attributes; fruits with poor and non-uniform maturity and shelf life, low and non-uniform oil content and physical defects. Poor qualities associated with nutrient deficiency, physiological disorders, undersized and deformed fruits
5	Harvesting	Harvesting immature fruits, using inappropriate harvesting methods and tools; damage during harvesting from tall trees, removal of fruit stalks, harvesting during rainy time, soils and dirty materials not removed, meeting less of GAP requirements	Visible defects and bruises, fruits rotting during transporting and storage Short shelf life during export, low-quality taste
6	Handling and transporting to the local/main markets	Stacking together and use of inappropriate handling materials like plastic bags that cause physical damage, Un availability of farm roads, and use of pack animals, animal-drawn carts, and humans under unsafe conditions	Shortens shelf life due to high temperature build up with consequences on subsequent value chains; bruises and internal damage on fruits, contamination with dirt and other contaminants; exposure to rain favoring the development of fungi on bruises
4	Aggregation/ collection	Use of inappropriate handling materials and collection facilities example on open and hygienic field grounds, and truck floors compromising food safety and exposing fruits to damage; bulking, stacking, and trampling by the foot of laborers	Visible bruise, rotting fungal development, unfit for consumption, damage caused by high temperature
5	Long distance transporters	Inappropriate transport means (not controlled atmosphere); no or limited use of appropriate handling materials while transporting (crates), unhygienic and dirty surfaces of trucks used; inappropriate inspection methods	Visible bruise, fungal development and rotting, accelerated respiration and reduced keeping quality, fungal development, unfit for consumption

6	Wholesaler	No controlled atmosphere storage; unsafe or unhygienic handling, contamination with soils and dirty materials from the field, trucks, and store; no or little sorting, and grading practice	Visible bruises, fungal development and rotting, reduced keeping quality, deterioration of quality, unfit unappealing for consumption,
8	Retail market	Except for supermarkets with better storage and marketing facilities, juice shops, street vendors, and petty traders have no CA storage and marketing space; and little or no sorting and grading practice; placing fruits in unhygienic and dirty spaces exposes them to also sunlight and rain.	Visible bruise, physical and physiological deterioration; rotting unappealing for consumption; high post-harvest loss
9	Quality control and regulation	Inadequate or incomplete standards; inadequate enforcement mechanisms; no supplies to meet standards; hence the prevalence of unsafe fruit handling across the value chain	High risk of food-borne infection; no incentive for value addition to improve safety and quality; limited competitiveness in the market.

Water constitutes the primary component of avocado fruit products, resulting in their bulkiness and low value per unit. This characteristic renders transportation from production sites to distant consumers costly. Avocado fruits are inherently bulky, highly perishable, and pose significant risks, complicating the harvesting and postharvest management processes. These phases can account for as much as 60% of total costs within the horticultural production and marketing system, with nearly 50% of the fruit ultimately going unconsumed (Hoffman *et al*., 2012).

Poor harvesting techniques and subsequent supply chain management (Maney et al., 2024) contribute to an increased risk of quality loss, particularly as the time from harvest to consumption increases. This issue is exacerbated by the fact that a significant amount of avocado production occurs in high rainfall regions such as Jimma, Kaffa, Shaka, and Illuababora, which are located 400 to 700 kilometers away from Addis Ababa and are hindered by inadequate road infrastructure.

3.7.3. Avocado Harvest and Postharvest Loss Estimation – A Load Tracking Method

The study utilized a load-tracking approach to accurately assess the losses experienced during the harvesting and postharvest stages of avocados along the value chain in the Boditi and Bonga production regions, supplemented by direct observations. The loss estimate was done at five key avocado supply chain stages: the loss at harvesting stage (SC 1), during the loading, transport, and unloading at the wholesalers (SC 2), at the storage facilities when retailers procure their fruits (SC 3), during the time spent in wholesale storage and the subsequent distribution to retailers (SC 4), and the retail sale of whole fruits (SC 5).

3.7.3.1. Loss of avocado fruits during harvesting (SC 1)

The precise harvesting dates for avocado fruits are determined by the dry matter and oil content of the ripening fruits; however, assessing these quality characteristics while maintaining a continuous harvest at the farmer's level presents significant challenges. This problem is especially pronounced for green skin avocados, where there is no visible color change. In

contrast, for black and purple/brown skin varieties, farmers typically harvest when the fruit turns from green to brown/purple or black.

As outlined in prior sessions, farmers adopt a range of harvesting techniques for avocado fruits. When dealing with shorter grafted trees, they typically use hand picking along with harvesting bags. For taller trees, the methods include hand-picking and dropping the fruits, utilizing harvesting poles, or shaking the trees to dislodge the avocados. This approach can result in postharvest losses, attributed to immature fruits and physical damage incurred during the harvesting, particularly with taller trees (Figure 3.7.3).

Figure 3.7. 3: Avocado fruits harvesting method in Kaffa

Assessing the quality degradation of avocado fruits poses a significant challenge, as some losses are difficult to quantify due to their subjective nature, especially regarding consumer appeal. Generally, the dimensions of quality loss include buyer acceptability, weight loss, reduction in caloric and nutritional value, loss of edibility, diminished market quality, and the appearance of external bruises on the fruit's surface resulting from inadequate handling (Figure 3.7.4).

Figure 3.7. 4: Sorted out deformed avocado fruits

The findings of this study indicated that the average **total loss** of avocados during the harvesting phase was 9.52%, consisting of 5.5% losses related to **quality** and 4.02% losses associated with **quantity**. The avocados collected from the Boditi and Bonga production regions exhibited comparable total losses of 8.9% and 8.87%, respectively (Table 3.7.19). Several factors contribute to the loss of avocado fruits, such as the harvesting of immature fruits, inadequate harvesting techniques, and substandard management practices thereafter. While minor bruising of the flesh may occur during the picking process, it is expected to escalate after the fruits are bulked and begin to ripen. Consequently, improper harvesting practices can result in significant losses for farmers, transporters, wholesalers, and retailers.

Table 3.7. 19: Average quantity and quality loss of avocado fruits at harvesting (SC 1)

Parameters	Production areas (%)		Mean
	Boditi *	Bonga *	
Qualitative loss (%)	4.62	5.65	5.5
Quantitative loss (%)	4.28	3.22	4.02
Total loss (%)	8.90	8.87	9.52

*= Mean of three farmers, with mean of three samples per sample farmer

3.7.3.2. Loss of avocado fruits during loading, transportation and unloading (SC 2)

The majority of farmers located away from main roads utilize local transportation methods, including motorcycles, animal-drawn carts, and tricycles (commonly referred to as Bajaj), to convey fresh avocado fruits to nearby markets and aggregation centers (Figure 3.7.5).

Following the sorting of the sample fruits, the sound fruits were placed into soft nylon net bags, which were then tied and loaded onto an ISUZU truck in various positions alongside other fruits for their transport to Addis Ababa. Avocados from Boditi are generally packed in grain-like sacks prior to loading, whereas avocados from Bonga are simply bulked onto the truck without any sacks or additional containers (Figure 3.7.6).

Figure 3.7. 5: Avocado fruits transportation to the local market by producers

Figure 3.7. 6: Loading avocado fruits at Boditi to transport to AA and other markets

The methods of transporting avocado fruits over long distances differ across various regions. In southern Ethiopia, specifically in Boditi, transporters utilize sacks to package avocados for sale in local markets and aggregation centers, facilitating their loading and transport to more distant markets. Conversely, in areas such as Bonga and Jimma, avocados are loaded onto ISUZU trucks without any form of compartmentalization for transport to far-off cities, including Addis Ababa

Figure 3.7. 7: Sample avocado fruits ready for transporting to AA Haile Garment

The loss of avocado fruits during loading, transportation, and offloading from ISUZU/FSR trucks was assessed at wholesalers in Addis Ababa following their transport. The fruits were moved in bulk without any protective measures, such as shock absorbers or controls for temperature and relative humidity. Consequently, the transportation conditions were poor, compounded by insufficient facilities. Additionally, the poor state of transportation infrastructure adversely impacted the bulk fruits as the trucks traversed rough roads. The sample avocado fruits were placed at different locations in the bulk on trucks for long distance transportations as indicated in Figure 8.6. Upon arrival at the Haile Garment central market in Addis Ababa, the fruits were offloaded and categorized into three groups: that experiencing quantity loss, those with quality loss, and sound fruits proceeded to the next stage of the supply chain. The evaluation indicated that the average losses of avocado fruit in terms of quality, quantity, and total during the processes of loading, transportation, and offloading were found to be 4.78%, 3.04%, and 7.82%, respectively. The quality, quantity, and overall losses varied from 5.6% to 3.97%, 5.08% to 1.0%, and 10.68% to 4.97%, respectively, for products obtained from the Boditi and Bonga production regions (Table 3.7.20).

Table 3.7. 20: Average loss of avocado fruits during transportation to aggregation points (SC 2)

Parameter	Average loss of fruits		Mean
	Boditi*	Bonga*	
Qualitative loss (%)	5.60	3.97	4.78
Quantitative loss (%)	5.08	1.00	3.04
Total loss (%)	10.68	4.97	7.82

**= Mean of three farmers, with mean of three samples per sample farmer*

Figure 3.7.3.2. 1: Avocado fruits loaded on a truck from Bonga for load tracking

3.7.3.3. Loss of avocado fruits in transporting to main destination market (SC 3)

The deterioration of avocado fruits increases with the progression of ripening. Ineffective harvesting methods, the removal of stalks, and improper practices in loading, transporting, and offloading, as well as other management shortcomings, significantly accelerate ripening and cause physical damage. As a result, fruits that have reached ripeness begin to rot at this stage.

The investigation revealed that the average qualitative, quantitative and total losses of avocado fruit at wholesale storage were measured at 0.64%, 2.29%, and 2.92%, respectively. From the fruits sourced in the Bonga area, no qualitative losses were recorded at this stage, although a quantitative loss of 1.7% was recorded. Fruits from the Boditi area exhibited qualitative, quantitative, and total losses of 1.27%, 2.88%, and 4.15% (Table 3.7.21). The cause of loss during these phases of avocado is generally linked to previous management deficiencies, as well as lack of proper storage conditions with poor temperature management along the supply chain with increased mechanical injury.

Table 3.7. 21: loss of avocado fruits during transportation to main destination market (SC 3)

Parameters	Loss of avocado fruits		Mean
	Boditi*	Bonga*	
Qualitative loss (%)	1.27	0.0	0.64
Quantitative loss (%)	2.88	1.7	2.29
Total loss (%)	4.15	1.7	2.92

**= Mean of three farmers with mean of three samples per sample farmer*

3.7.3.4. Estimated loss of avocado fruits during wholesale storage (SC 4)

The overall loss of avocado fruit during the wholesale storage period and subsequent distribution to retailers was determined to be 11.1%, comprising 3.0% in qualitative losses and 8.1% in quantitative losses. Avocado fruits transported from the Boditi area experienced a greater loss of 15.27% in comparison to those sourced from the Bonga production area (6.97%), (Table 3.7.22).

Table 3.7. 22: Estimated loss of avocado fruits during wholesale storage (SC 4)

Parameters	PH loss SC 4		Mean
	Boditi*	Bonga*	
Qualitative loss (%)	4.34	1.67	3.00
Quantitative loss (%)	10.93	5.30	8.11
Total loss (%)	15.27	6.97	11.12

**= Mean of three farmers with mean of three samples per sample farmer*

3.7.3.5. Estimated loss of avocado fruits at retailers' level (SC 5)

The loss of avocado fruits continues throughout the trading process until they reach the point of consumption. A significant number of consumers favor the purchase of ripe, ready-to-eat avocados. Conversely, retailers face challenges in managing ripe fruits, as losses can occur if these items are not sold at the right stage. The extent of loss at the retail stage is influenced by the cumulative handling and ripening processes that occurred prior. Fruits harvested with the fruit stalk completely removed tend to begin ripening at the tips where the stalk was attached. Both pathological and physiological deterioration escalates during storage. Failures in packaging and improper temperature management during transportation become evident at the end of the supply chain. Additionally, losses due to decay and water loss increase among retailers, leading to further rotting if the fruits are not sold before their expiration dates.

In the present study, avocado fruits experienced an average total loss of 7.35% during retail, which comprised 5.14% in qualitative losses and 8.25% in quantitative losses. Fruits collected from Bonga experienced a total loss of 17.19%, which is considerably greater than the 7.79% loss recorded for fruits from Boditi area (Table 3.7. 23).

Table 3.7. 23: Estimated loss of avocado fruits at retailers' level (SC 5)

Parameters	PH loss		Mean
	Boditi*	Bonga*	
Qualitative loss (%)	4.28	6.00	5.14
Quantitative loss (%)	3.51	11.19	8.25
Total loss (%)	7.79	17.19	7.35

**= Mean of three farmers with mean of three samples per sample farmer*

Figure 3.7. 8: Appearance of avocado fruits during retail

3.7.3.6. Summary of avocado fruit losses estimated through a load tracking method

An analysis of avocado fruit loss conducted through the load tracking method demonstrated that the average total loss from the two sampling sites, Bonga and Boditi, amounted to 43.2%. This figure includes a quality loss of 18.7% and a quantity loss of 24.5%. The total average loss from the Bonga production area is calculated to be 39.7%, which includes a quality loss of 17.3% and a quantity loss of 22.4%. On the other hand, the Boditi production area recorded a higher total avocado fruit loss of 46.8%, with quality loss at 20.1% and quantity loss at 26.7%. Avocado losses from the Boditi region are generally more pronounced than those from the Bonga area. This may be due to the specific characteristics of the fruits, as avocados from southern Ethiopia, such as the Wolaita area, have a notably thinner skin in contrast to the thicker-skinned avocados found in Jimma and southwestern Ethiopia, including the Bonga-Mizan Teferi production areas, which are more resistant to rough handling. This illustrates that the efficiency of avocado harvesting and the management of the subsequent supply chain is considerably poor, causing nearly half of the produced quantity to be lost at various stages of the supply chain.

3.7.3.7. Critical avocado loss points

Critical loss points (CLP) are stages or points in the supply chain (SC) where food losses have the highest magnitude, the highest impact on food security, and the highest effect on the economic result of the SC. Loss points for avocado fruits are predominantly identified at several stages: during harvesting, when transporting to the aggregation centers, during the loading, transportation, and offloading to the central market, during storage at the wholesale market, and while transporting to the retail market, and retailing. The average total loss of avocado fruits obtained from the two study sites indicated that the Critical loss Points were observed at the retail market (12.5%), during wholesaler storage and marketing (11.2%), and at the harvesting stage (8.9%), in that sequence. Conversely, the loading, transportation, and offloading to the central market (SC3) appears to be a Low Loss Point (LLP), where the losses are surprisingly minimal (Table 3.7.24).

Table 3.7. 24: Summary of avocado fruit critical loss points along the supply chain

SC	**Boditi**	PH loss (%)		Total loss (%)
		Qualitative loss	Quantitative loss	
1	Harvesting (SC 1)	4.6	4.3	8.9
2	Transportation to aggregation place (SC 2)	5.6	5.1	10.7
3	Loading-transportation-offloading to central market (SC3)	1.3	2.9	4.2
4	Wholesale market storage (SC4)	4.3	10.9	15.3
5	Transportation to retailers' market and at time of retailing (SC5)	4.3	3.5	7.8
	Sub-Total	**20.1**	**26.7**	**46.8**
	Bonga			
1	Harvesting (SC 1)	5.7	3.2	8.9
2	Transportation to aggregation place (SC 2)	4.0	1.0	5.0
3	Loading-transportation-offloading to central market (SC3)	0.0	1.7	1.7
4	Wholesale market storage (SC4)	1.7	5.3	7.0
5	Transportation to retailer markets and at time of retailing (SC5)	6.0	11.2	17.2
	Sub-Total	**17.3**	**22.4**	**39.7**
	Cumulative Average	**18.7**	**24.5**	**43.2**

**= Mean of three farmers with mean of three samples per sample farmer*

Future studies regarding the postharvest losses of avocado fruits ought to encompass more remote production zones within the country, as well as distant markets, and should include an examination of commercial varieties such as the Hass variety along both domestic and export supply chains.

3.7.4. Annual national postharvest loss of avocado fruits

Both quantity and quality loss of avocado occur every year and these losses were estimated and changed into economic losses as per calculated below, taking 18.7% of annual total production get qualitative loss and 24.5% of the total production get quantitative loss by taking 2020/2021 production year with the total production of 259,998,000 kg (CSA, 2020/2021) from small holder farmers cultivating on an estimated area of 30,587.74 ha (Table 3.7.25). The price of normal and low-quality avocado fruits was obtained from different supply chain actors during the load tracking method. The study found that the annual economic loss of avocado fruits in Ethiopia was estimated to 5,129,760,540 (five billion, one hundred twenty-nine million, seven hundred sixty thousand, five hundred forty) Birr as shown Table 3.7.25. The losses increase with the increase of avocado production areas and with increase in avocado productivity. Further, the loss increases with the destination market distance from the production areas and thus vary with years and production areas. In addition, high quantitative PH losses of avocado occur during the avocado oil processing supply chain stages that requires further study. Thus, any optimization of PH management practices that reduces avocado PH loss would minimize the corresponding economic losses of avocado fruits and improves national food security.

Table 3.7. 25: Estimated annual loss of avocado fruits in Ethiopia in monetary terms

Description	Amount
Area of production (CSA, 2020/2021)	30,587.74 ha
Productivity (yield, kg/ha), (CSA, 2020/2021)	8,500 kg
Total production during 2020/2021 year	259,998,000 kg
Qualitative loss	18.70%
Quantitative loss	24.50%
Average value of low-quality fruit at Addis Ababa retail price	10 birr/kg
Amount of qualitative loss (kg)	18.7% X 259,998,000 = 48619626
Amount of quantitative loss (kg)	24.5% X 259,998,000 = 63,699,510
Average value of quality avocado fruit at Addis Ababa retail price	50 birr/kg
Value difference of low-quality fruit	40 birr/kg
Value of qualitative loss (Birr)	40 X 4861962600 = 1,944,785,040
Value of quantitative loss (Birr)	50 X 63,699,510 = 3,184,975,500
Value of total loss	1,798,146,168 + 2,913,277,590 =5129760540
Estimated total loss during the 2020/2021 production year in monetary terms	**5,129,760,540 Birr**

3.7.5. Causes of postharvest losses in avocado supply chain

A range of problems results in the loss of avocado fruits across the supply chain. The different causes of avocado fruit loss at various stages are presented in Table 3.7.26. Key causes include poor harvest maturity, poor harvesting practices, rough handling, mechanical injuries, and inadequate temperature management. These handling deficiencies continue to affect avocados at all stages of the supply chain until retailers manage to sell all the fruits to consumers.

Table 3.7. 26: Major factors in the avocado value chain that contribute to the loss of avocados

Critical Loss Point (SC stages)	Cause of loss
Pre-harvest (production)	- Poor field management (under size fruits, low yield, low fruit quality) - Insect/ wind damage –cause deformities -Abnormality/ deformities
Harvesting (SC 1)	- Poor harvest maturity - Poor harvesting methods - Rough handling practices - Mechanical injury (wind) - Poor temperature management
Transportation to the aggregation / collection centers/ local markets/ main markets	- Poor transportation condition and facilities - Rough, careless handling practices - Mechanical injury - Poor temperature management
Loading, transportation and offloading from ISUZU/FSR at the wholesaler in AA (SC 2)	- Poor long distance transportation condition - Poor transportation facilities, fruit bulking - Poor transportation infrastructure - Poor temperature management - Rough handling practices - Mechanical injury
Storage at the wholesaler when the retailers purchase fruits from wholesalers (SC 3)	- Poor storage conditions along all supply chains - Poor temperature management - Poor transportation condition - Rough handling practices - Mechanical injury
Wholesale storage time and distribution to retailers (SC 4)	- Poor storage conditions at wholesalers, retailers and supermarkets - Poor temperature management - Rough handling practices - Mechanical injury
When the retailers sell the whole fruits (SC 5)	-Poor storage conditions at retailers and supermarkets - Mechanical injury - Poor temperature management - No sorting of rotten, over ripen and unripe; all fruit put together

3.7.6. Comparison of survey and load tracking results for estimating avocado losses

Qualitative loss refers to foods that has incurred a reduction in economic value or nutritional value, but not in weight and everything will be eaten by people or when the food loses its quality attributes resulting in the deterioration in quality leading to a loss of economic, social and nutritional value. On the other hand, quantitative loss is the physical disappearance of food from the postharvest supply chain and not consumed due to, among other causes, spillage, consumption by pests and also due to physical changes in temperature, moisture content and chemical changes during postharvest operations from farm to markets.

The present study sought to assess the extent of avocado losses and pinpoint significant loss points within the harvest and post-harvest supply chain. To quantify both physical (quantity) losses and quality losses, the study employed two methodologies. The first involved conducting a field survey, where sample respondents provided self-reports, which were further validated through direct observation. The second method entailed the objective measurement of product loss throughout the supply chain, from harvesting to loading and offloading, transportation, and the wholesale and retail markets, using a load-tracking approach.

The analysis revealed that the total estimated loss using the survey method stands at 38.9%, which consisted of a quantity loss of 23.2% and a quality loss of 15.7%. Conversely, an assessment of avocado fruit loss using the load tracking method indicated an average total loss of 43.2%, with a quantity loss of 24.5% and a quality loss of 18.7%. This indicates that the objective measurement method (load tracking) yielded a total loss estimation that is 4% higher than that of the survey method. However, both methodologies produced comparable results in terms of quantitative loss, with the measurement method reflecting a marginal increase of 1%.

The findings of this study suggest that avocado losses occurring at harvest and throughout the subsequent supply chains in the studied regions are between 39% and 43%, with an average of 41%. Thus, it can be concluded that only roughly 60% of the total production of fresh avocados is successfully moved from producers to consumers within the supply chain.

3.8. Impact of Avocado Postharvest Loss

Postharvest losses have a dual impact: they not only decrease the economic value of the food produced but also result in the waste of essential resources such as labor, land, and water. In addition, these losses exacerbate the depletion of non-renewable resources, including fertilizers and energy, which is vital for the production, processing, handling, and transportation of food (FAO, 2011) In addition, food that remains uneaten by individuals or is not repurposed in any way can be disposed of as refuse, which has significant implications for the environment.

3.8.1. Estimated Impact in Monetary Value

According to the World Bank's income classification, a significant majority, specifically 94% of avocado growers in Ethiopia fall within the lower income bracket, defined as earning $1,135 or less. When examining regional variations, the figures reveal that 87.5% of farmers in Amhara, 94.9% in Central Ethiopia, 90.7% in Oromia, and an impressive 97.6% in South West Ethiopia are similarly classified. Transitioning between income categories will undoubtedly be accomplished if postharvest losses from avocados are minimized to a considerable figure.

At the national level, 5.4% of avocado growers are classified as lower middle income, earning between $1,136 and $4,465, with the Amhara region exhibiting the highest percentage at 12.5%,

while South Ethiopia shows no representation in this category, as all growers there are classified as lower income. Additionally, approximately 1.6% of avocado farmers in Oromia are categorized as upper middle income. A summary of regions classified by income group, in connection with avocado production and marketing, is illustrated in Table 3.8.1.

Table 3.8. 1: Proportion of avocado growers based on their per capita income

	Per Capita Income Category		
	Lower Income (%)	Lower Middle Income (%)	Upper Middle Income (%)
Amhara	87.5	12.5	0.0
Central Ethiopia	94.9	5.1	0.0
Oromia	90.7	7.8	1.6
Sidama	97.3	2.7	0.0
South Ethiopia	100.0%	0.0	0.0
South West Ethiopia	97.6	2.4	0.0
Overall	94.1	5.4	0.5

According to the CSA (2021), a total of 30,587.74 hectares was devoted to avocado production, yielding an overall output of 259,998,000 kilograms. The postharvest loss assessment conducted in this study, employing a load tracking technique, indicated that the quantitative and qualitative losses of avocados were 24.5% and 18.7%, respectively. When these losses are expressed in monetary value, based on the current market price for a kilogram of avocados, it amounted to a loss of 5.13 billion ETB for the 2021 production season. However, it is important to note that food loss refers to a reduction in food quantity prior to reaching the consumer level, which was initially intended for human consumption, irrespective of the underlying reasons. Consequently, even if the discarded food might have been repurposed for livestock feed, compost, or other use, the food that is not accounted for in this study is regarded as a loss.

3.8.2 Impact on Human Nutrition

To assess the nutritional loss attributed to postharvest loss of avocados, it is necessary to identify both the nutritional composition of the avocado fruit and the daily nutrient requirements for an adult. According to the USDA (2019), avocados are abundant in numerous macro and micronutrients, as shown in Table 3. For instance, one kilogram of avocado yields 1600 kcal of energy, 150 g of total fat, 210 µg of vitamin K, and 4850 mg of potassium. Other macro and micro nutrients available in the avocado fruit are summarized below in Table 3.8.2.

Table 3.8. 2: Macro and micro nutrient contents of avocado fruit pulp

Macro and micro nutrients	Amount/kg
Energy	1600 kcal
Protein	20 g
Total Fat	150 g
Carbohydrates	90 g
Dietary Fiber	70 g
Sugars	7 g
Vitamin K	210 µg
Foliate	810 µg
Potassium	4850 mg
Magnesium	290 mg
Vitamin E	20 mg

Source: USDA, 2019

The joint action global guideline from the Food and Agriculture Organization (FAO) and the World Health Organization, WHO (2004) serves to provide recommendations for nutrient intake that support optimal health. It delineates the daily nutrient requirements for individuals, known as Recommended Nutrient Intakes (RNIs), which align closely with the Recommended Dietary Allowances (RDAs) established by other agencies. These recommendations are tailored according to age, gender, and life stage. The recommended daily consumption of general nutrients for an adult is shown in Table 3.8.3.

Table 3.8. 3: Daily Nutrient Intake Recommendations for Adults FAO/WHO (2004)

Nutrient	Recommended Intake
Calories	2000-2500 kcal/day
Protein	0.8 g per kg of body weight
Total Fat	20-35% of total daily energy intake
Carbohydrates	45-65% of total daily energy intake
Fiber	25-30 g/day
Sugars	Less than 10% of total energy
Sodium	Less than 2 g/day (2000 mg/day)
Potassium	At least 3.5 g/day (3500 mg/day)
Calcium	1000 mg/day
Iron	8 mg/day (men); 18 mg/day (women)
Zinc	11 mg/day (men); 8 mg/day (women)
Magnesium	310-420 mg/day
Vitamin A	700-900 µg/day
Vitamin C	75-90 mg/day
Vitamin D	10-20 µg/day
Vitamin E	15 mg/day
Folate	400 µg/day
Vitamin K	90-120 µg/day

The two tables presented above provide essential data that enables us to assess the nutritional consequences of avocado postharvest loss in Ethiopia. It has been determined that Ethiopia experiences an annual loss of 58,239,552 kg of avocado fruits. For commercial varieties, the avocado pulp constitutes 65–73% of the total fruit weight. However, considering the larger seeds found in local varieties, we adopted a more conservative estimate of 55% for our calculations. Based on this proportion, the total quantity of avocado pulp lost due to postharvest management throughout the supply chain is estimated to be 35,034,730.5 kg. Consequently, this loss translates to a deficit of 56.1 billion kcal of food energy, along with various macro and micronutrients, as illustrated in Table 3.8.4. In this regard, the lost avocado pulp could have satisfied the annual food energy needs of 61,431 adults, the protein requirements of 2,399,639 adults, and the carbohydrate needs of 5,316 adults. Furthermore, from a micronutrient perspective, the lost avocado fruits could have met the annual nutrient requirements of 194,371 adults for folate, 133,009 adults for potassium, and 66,276 adults for magnesium, as detailed in Table 3.8.4.

Table 3.8. 4: Nutritional Impact of avocado fruit postharvest losses

Nutrients	Nutrients/ kg of Avocado	Unit	Daily requirement per adult person	Estimated Loss of avocado pulp in kg/year	Total Loss of Nutrients/year	Number of people who could be nourished /year
(a)	(b)		(c)	(d)	(e=b*d)	f=(e/c)/365
Energy	1600	kcal	2500	35,034,730.50	56.1 billion kcal	61,431
Protein	20	g	0.8		700,694,610	2,399,639
Total Fat	150	g	875		5,255,209,575	16,455
Carbohydrates	90	g	1625		3,153,125,745	5,316
Fiber	70	g	30		2,452,431,135	223,966
Folate	810	µg	400		28,378,131,705	194,371
Potassium	4850	mg	3500		169,918,442,925	133,009
Magnesium	290	mg	420		10,160,071,845	66,276

Source: Analysis result of avocado PHL assessment

3.8.3 Impact on food security

As indicated in the previous section, Ethiopia incurs an annual loss of 5,129,760,540 birr due to postharvest losses of avocado fruits when expressed in monetary terms. At the prevailing market price of wheat in Addis Ababa, this sum could purchase 73,282,293 kg, or 73,282 metric tons, of wheat. Furthermore, an average adult requires 2,500 kcal of food energy daily, and one kilogram of wheat provides 3,400 kcal, as reported by the FAO (1985, 2004,). Consequently, this translates to a loss of 249.16 billion kcal of food energy, sufficient to sustain 99,663,919 adults for one day or 136,526 adults for an entire year, as illustrated in Table 3.8.5.

Table 3.8. 5: Food security implications of the avocado postharvest losses

Description	**Unit**	**Quantity**
Economic loss of Avocado	ETB	5,129,760,540
Price of Wheat/kg	ETB	70
Volume of wheat that could be purchased with the lost money	Kg	73,282,293
Energy content of wheat/kg	kcal	3,400
total lost energy	kcal	249,159,797,657
Energy requirement of adult person/day	kcal	2,500
Number of adults that could be fed/day	Person	99,663,919
Number of adults that could be fed/year	Person	273,052
Number of adults that could be food secured/year, if we reduce the loss by 50%,	Person	136,526

3.8.4 Impact on land resources use efficiency

The analysis of postharvest losses for avocados in Ethiopia demonstrates a considerable quantitative loss of 63,699,510 kg, or 63,699.5 metric tons of avocado fruits. Taking into account the current productivity level of 8,500 kg per hectare, the amount lost would have necessitated 7,494 hectares of land for its production. Therefore, the inefficiencies in the avocado production and marketing systems have caused 7,494 hectares of land to remain unproductive on an annual basis in Ethiopia, as presented in Table 3.8.6.

Table 3.8. 6: Impact of avocado fruits postharvest loss on land utilization

Resources	Estimated quantitative loss (kg)	Estimated average productivity kg/ hectare	Estimated land resource (ha) wasted due to the loss/year
(a)	(b)	(c)	(d= b/c)
Land (ha)	63,699,510	8500	7,494

3.8.5 Impact on the environment

The assessment of postharvest losses in avocados indicated that the disposal of 63,669.5 tons of avocado solid waste necessitates a total of 9800 medium-sized dump trucks, each with a capacity of 6.5 tons. Furthermore, the average carbon footprint associated with avocados is approximately 2.5 kilograms of CO_2 equivalent (kg CO_2e) per kilogram. This figure encompasses all greenhouse gas emissions linked to the production and transportation of avocados, including carbon dioxide, methane, and nitrous oxide, expressed in terms of their CO_2 equivalent impact. Notably, the carbon footprint of avocados is more than double with that of bananas (0.9 kg CO_2e per kg) and over five times that of apples (0.4 kg CO_2e per kg), (Smith, J. 2024). Taking these considerations into account, the loss of 63,669.5 tons of avocados has led to greenhouse gas emissions totaling 159249 tons of CO_2 equivalents (CO_2e), as detailed in Table 3.8.7.

Table 3.8. 7: Estimated Greenhouse gas emissions from disposal of avocado wastes

Types of environment impact	Estimated quantitative loss (kg)	Municipal Solid waste contribution (tons)	Amount of Greenhouse Gas emission/kg	Total Greenhouse Gas emission	Volume of land fill dump track	Number of land fill dump tracks required for disposal of waste(g) = b/f
(a)	(b)	c=(b/1000)	(d)	(e)= c*d	(f)	
Solid waste contribution	63,699,510	63,669.5 tons			6.5 ton	63699.5/6.5 ton = 9800 dump trucks
Greenhouse gases emission	63,699,510	63,699.5 tons	2.5 kg CO_2 e	159248.8 tons of CO2 e		

3.9. Avocado Fruit Export Market

The demand for fresh avocado is expected to rise sustainably in the world due to increasing demand for avocado derived processed food; functional food; cosmetic products. Mexico is the number one avocado producing and exporting countries in the world. Kenya, South Africa and Morocco are the leading avocado exports in Africa. The export of avocado fruits in Ethiopia represents a relatively recent advancement, having emerged within the last decade. Since the initiation of avocado exports, significant awareness has been created among various stakeholders in the value chain, beginning with nursery, inputs, and field production, and extending to the organization of farmers into cluster Primary Cooperative Associations. Additionally, efforts have been made to engage youth and groups in the production of avocados. Presently, the avocado sector has created employment opportunities for millions of individuals throughout the value chain and supply chain stages, surpassing the job creation potential of other crops. Numerous media outlets and international news organizations, including the UN Global Perspective Human Stories, have reported on this development, highlighting that Ethiopian avocado may become the country's future green gold, akin to the coffee industry (Freshela Exporters, 2024; EHPEA, 2019; FAO, 2021; Endale, 2019). Trading companies have made efforts to export graded and sorted, as well as ungraded avocado fruits annually to Europe and the Far East. The export of avocados to developed nations, including those in the European Union, necessitates compliance with Global GAP, GRASP, and various other certifications. This section of the report is derived from interviews with various exporters, export support organizations, and individuals engaged in the avocado export supply chain.

3.9.1. Certification of avocado farm and the systems

Avocado exporters are anticipated to engage with importing companies and adhere to the requirements set forth by these companies and their respective countries. Many developed nations have established and adopted stringent standard requirements that pertain not only to the products themselves but also to the social and environmental conditions under which avocado fruits are grown. Once exporters successfully navigate all necessary procedures and obtain the Global GAP and GRASP certifications, they will begin sourcing avocado products.

A variety of farm assurance certifications are necessary for the export of avocado fruits to the European Union and certain countries in the Far East. The required certifications include: 1) Global GAP Integrated Farm Assurance; 2) SEDEX: Empowering Sustainable Supply Chains (Sedex, 2024); 3) SMETA (SEDEX Members Ethical Trade Audit); 4) Global GAP GRASP (The GLOBALG.A.P. Risk Assessment on Social Practice); 5) Rainforest Alliance Farm Assurance; 6) Sustainable programs for irrigation and groundwater use; and 7) Organic certification. All stakeholders involved in the avocado export value chain in Ethiopia should aim to obtain these certifications.

However, the landscape of exporters and participants across the avocado value chain and supply chain is characterized by disorganization and fragmentation. Actors within the same value chain often do not know or communicate with one another, and centralized control and management are absent. Additionally, many are not fully informed about the precise requirements of global avocado markets, including Global GAP and other essential certifications for export, as well as the fierce competition facing them from other avocado-producing countries in the global market, particularly regarding the supply of high-quality avocado fruits. At any given stage of the

avocado value chain and supply chain, complete information is elusive, and documentation practices are generally poor. It is therefore imperative that avocado exporters are structured in a way that enables them to engage effectively with supporting value chain actors. If avocado exporters are well-organized, they can gain significant power and influence over the government to secure substantial support for the advancement of the avocado industry. This organization will enable them to establish strategies for achieving the highest brand recognition and superior quality of Ethiopian avocado fruits in global markets. Additionally, they will be able to predict future market needs for avocado products and take necessary actions to support all stages of the value chain and supply chain.

The farms designated for export must undergo yearly audits, with their certifications being renewed on an annual basis. To obtain Global GAP, GRASP, and other certifications, Primary Avocado Growers Cooperatives must conduct internal audits that adhere to the standards set by Global GAP, GRASP, and ISO, aligning with the best practices outlined by the importing companies' guidelines. These internal audits serve to prepare avocado farms for the subsequent external audits, which are conducted by the Control Union (CU) in Ethiopia.

3.9.2. Sourcing of avocado fruits for export

The Hass variety currently dominates avocado exports from Ethiopia. Exporters in the country do not possess their own farms; rather, they buy Hass avocados from Primary Avocado Growers Cooperatives, unorganized avocado cluster growers, and individual farmers who have planted the Hass variety in various regions. These exporters collect fresh Hass avocados and engage with Unions, Primary Cooperative Associations, and the RBoA. After reaching a Memorandum of Understanding (MoU) with various supply chain participants, they commence preliminary arrangements with importers concerning the specifications for fresh fruit, which include Maximum Residue Levels (MRL) testing and securing Global GAP Certification through Control Union, along with agreements with packhouse operators, cold logistics, and transport service providers like Ethiopian Cargo and Railway.

Avocado exporters in Ethiopia are actively sourcing Hass fruits from a variety of producers across regions where this variety is cultivated annually. For instance, in the year 2024, DH GADA Trade and Industry Plc. gathered fresh Hass avocados from farmers located in Jimma, Buno Bedele, Illuababora, and other administrative zones within Oromia. These fruits were subsequently transported to Koka for packaging and further cargo and inland operations (Figure 9.1). There is a significant need for support for all avocado exporters in Ethiopia, which includes assistance from Primary Avocado Producers Cooperatives/Unions, the Ministry of Trade and Regional Integration (MoTRI), the Ministry of Transport and Logistics (MoTL), the Ministry of Revenue, financial institutions, Ethiopian Railway Cooperation, the Ministry of Agriculture (MoA), the Regional Bureau of Agriculture (RBoA), and other relevant organizations. The support provided by these entities is crucial for Ethiopian avocado exporters to compete effectively in the global avocado market.

Securing quality fruits is a challenging endeavor, and exporters face uncertainty regarding the availability of adequate quantities and quality of Hass avocados from smallholder farmers. The minimum quantity required to fill a single container is 200 quintals. The difficulty in obtaining high-quality fruits that adhere to optimal maturity standards is exacerbated by the inconsistent management practices employed by various farmers. While certain farmers effectively manage their avocado trees, many do not provide the necessary oversight, resulting in a range of

management practices that contribute to variable fruit sizes, often yielding undersized avocados with low productivity. Emergences of Quarantine Pests like persea mite, false codling moth are some of the threats that may affect the expansion of avocado export trade.

One of the significant challenges faced by exporters is that the domestic market price for Hass avocado fruits consistently exceeds the prices offered by exporters. After purchasing the avocados, exporters incur additional expenses for each kilogram, which include local transportation to the packhouse, sorting and grading operations (ranging from 6 to 9 Birr per kilogram), packaging materials, pelleting costs, and both inland and cargo transportation. Without substantial improvements in field production, productivity, harvesting, and post-harvest handling of the Hass avocado variety, the competition between domestic supply and exports remains intense, necessitating coordinated efforts for the advancement of the national avocado industry. Diagnosis and recommendation on mitigation of nutrient deficiencies, physiological disorders and injuries, and pests and diseases that affect postharvest qualities are imperative to enhance competitiveness of the Ethiopia avocado export industry.

Figure 3.9. 1: Avocado export operation in Manna Kerssa, Jimma Zone

In 2024, all avocados sourced from various regions across the country were processed at Ethio-Veg Fruit Farm Plc, situated in Koka (Figure 3.9.2). Furthermore, another exporter collects Hass variety fruits from various distant locations in Ethiopia. These fruits are then transported over a distance of 400-500 kilometers to Koka for packaging, without any temperature control measures in place. This absence of temperature regulation during transportation from the farms to the packhouse negatively influences the quality of the fruits by the time they are exported.

Figure 3.9. 2: Hass avocado fruits under sorting and grading for export

Strengthening the avocado export value chain is instrumental in achieving various global certifications. To successfully export avocados from Ethiopia, all participants in the value chain should aim for certifications such as the Risk Assessment on Social Practice (GRASP), Rainforest Alliance farm assurance, and Organic certification. This helps to minimizing the rejection rates of avocado fruits that do not meet quality standards at the early stages of the supply chain, including issues like small size, bruises, surface cracks, or other undesirable characteristics, and provide substantial benefits to the country. It is vital to identify key areas for intervention within the value chain and supply chain stages, understand the reasons behind existing challenges, and suggest viable interventions for the avocado export chain in Ethiopia. The export chain involves numerous partners and stakeholders, and avocado exporters are currently facing constraints such as a shortage of avocado fruits, limited transportation facilities, and logistical challenges within the country. All stakeholders must work together to fulfill the requirements of the avocado export market in Ethiopia (Table 3.9.1).

Presently, exporters are not receiving adequate support from the Ministry of Trade and Regional Integration (MoTRI) or Regional Cooperative Agencies, Unions, and Primary Cooperatives. This situation reflects the absence of well-defined legal structures that facilitate the support of producers and export systems. The current methods of avocado export appear to be unsustainable, relying heavily on numerous interfaces and multiple Memoranda of Understanding (MoUs) among exporters and other key stakeholders. When issues arise, it becomes challenging to rectify them, and identifying the source of the problem can be equally difficult. Brokers and local traders can jeopardize the integrity of many MoUs at any stage. Therefore, it is imperative to undertake a thorough mapping of the avocado export supply chain, ensuring that stakeholders and their roles are clearly defined to improve the export of avocado commodities.

Table 3.9. 1: Role of VC Actors in exporting avocados from Ethiopia

Actors	Cases (agreement)
Growers	Supply of high-quality fruits –Hass variety (Primary Cooperative Associations/ Unions) and non-clusters
Transporters	Transport fresh avocado fruits to the packhouse
Laboratory Services	MRL testing (Accredited Lab is in Kenya)
Control Union (PLC)	Global GAP certification in Ethiopia
Packhouse (PLC)	Grading and sorting (few packhouses exist in Ethiopia)
Storage (PLC)	Temperature management along the export chain
Inland transport services providers (PLC)	Transporters (Airport, Cargo transport, and inland transport)- cool chain logistics, shipping, and sea freight
Foreign buyers (importers)	Promotion, testing all fruit quality characteristics including MRL on arrivals, before dispatching to the various whole sellers in foreign countries

3.9.3. Avocado growers cooperatives

A significant number of avocado producers, encompassing both commercial Hass variety growers and those cultivating local avocado types, are organized into primary agricultural cooperatives. In the realm of commercial cultivation, there are only a few small-scale cluster growers who have established cooperatives. Prominent among these small-scale avocado cluster cooperatives are the Meskan Avocado Growers Cooperative located in the Central Ethiopia Region, the Hundaol Avocado Growers Cooperative in the Oromia Region, and the Selam Horticulture Cooperatives. Presently, Hass avocado fruits are certified by these cooperatives,

with many members engaged in exporting fresh avocados to Europe and Gulf countries, adhering to Global GAP Certification standards.

Despite the growing number of farmers producing the Hass avocado variety across various regional states in Ethiopia, there remains a lack of organization among avocado growers into primary cooperatives and unions. This disorganization complicates the process of obtaining Global GAP certification. It is imperative that Hass avocado growers establish Primary Cooperative Associations and Unions to facilitate farm audits and streamline the Global GAP certification process.

The Global GAP certification is exclusively granted to licensed primary avocado cooperative producers. It is not feasible for scattered growers to export avocado fruits, as they are unable to obtain Global GAP certification due to the complexities involved in farm auditing. Therefore, all avocado farmers in Ethiopia who wish to engage in avocado export must be organized into primary cooperatives across all Woredas, Zones, and Regions. The Federal Cooperative Commission, along with Regional Cooperative Agencies, should facilitate the organization of small-scale avocado clusters to achieve this objective. Furthermore, each primary cooperative of Hass avocado growers should employ their own experts, either individually or collectively, to ensure that the cooperative meets all Global GAP requirements. These experts will prepare the primary cooperative for internal audits and annual Global GAP certifications.

3.9.4. Packhouse processing and storage

The processing of avocados in packhouses for export employs a combination of manual labor and advanced machinery for grading. To ensure the avocados meet high-quality standards and the specified weight, 4 kg cartons are typically utilized for both air and sea shipments, contingent upon the buyer's specifications. Dry wooden pallets are selected for both modes of transport, taking into account the dimensions of the cargo and containers during transit. The cartons are arranged on the pallets according to the quantity required and the preferences of the buyers. It appears that there is a limited number of avocado packhouses in Ethiopia, necessitating further investigation to uncover challenges related to avocado packaging and the export supply chain in the country. Collaboration with exporters, logistics providers, and international buyers is essential to enhance consumer satisfaction.

The management of the avocado export chain heavily relies on effective storage practices. Adequate storage methods are vital for conserving the weight of the avocados, preventing softening, reducing water loss, and avoiding wilting, thus guaranteeing the freshness of the produce. One critical aspect is the pre-cooling of avocado fruits to 5° Celsius in cold storage rooms, which serves to eliminate field heat immediately after packaging. By maintaining controlled temperatures during storage, the shelf life of the avocados is guaranteed, allowing them to remain fresh throughout the supply chain and ensuring that customers receive high-quality fruits. This focus on quality enables customers to excel in the market. Further investigation is needed to pinpoint the primary challenges related to the storage and handling of avocado fruits until they reach consumers.

3.9.5. Loading, transport, and shipping of avocado fruits

Effective transportation of avocados at every stage of the supply chain hinges on the management of humidity, temperature, and load within containers, which are critical factors in preserving the quality of the fruit. It is essential to partner with reliable logistics providers who

can guarantee safe and timely delivery to international markets. During inland and export transportation, monitoring and tracking devices for temperature and humidity are employed in containers, ensuring comprehensive tracking from start to finish. Consequently, further in-depth study is imperative to enhance the quality of avocados exported from Ethiopia, enabling the country to compete effectively with other African nations and avocado producers from South and Central America, as well as various Asian countries.

3.10. Avocado Oil Processing

Many plants and plant-derived oils, such as avocado, are characterized by a high content of monounsaturated fats and a low presence of saturated fats. This composition may contribute to a reduction in harmful cholesterol levels while simultaneously increasing beneficial cholesterol levels, as well as enhancing the regulation of blood sugar levels. Consuming plant-based foods rich in monounsaturated fats may promote cardiovascular health and assist in the management of blood sugar.

Avocado oil has garnered significant attention in the realms of human nutrition, the food sector, and cosmetic applications. Its status as a sought-after global commodity is on the rise, attributed to its impressive nutritional benefits for health. The oil is derived from the pulp of ripe and well-matured avocados through a pressing process. In addition to its culinary advantages, avocado oil is advantageous for skin and hair care, delivering moisturizing and calming effects while safeguarding the skin from ultravioletray radiation exposure (Freshela Exporters, 2022).

Investing in avocado oil processing is a strategic move for enhancing the avocado value chain in Ethiopia, providing substantial benefits to both farmers and exporters. Smallholder farmers, who have primarily focused on the domestic market, now have the opportunity to supply their produce to oil factories that process avocados for export purposes. To take advantage of this emerging market, several avocado oil production facilities have been established across Ethiopia.

3.10.1. Avocado oil processing plants

Ethiopia currently boasts nearly twelve factories dedicated to the production of crude avocado oil. The majority of these facilities are situated within the Agro-Industry Parks located in the Sidama and Gedeo Zone of South Ethiopia, as well as in the Oromia region, specifically the Jimma Zone (Figure 3.10.1.1). Among the leading companies in this sector are SUNVADO Ethiopia, YBM Avocado Oil, Aevo Ethiopia, Green Gold, and Soreti Avocado, which have commenced the production of organic crude, extra virgin, and refined avocado oil sourced from organic avocados grown in southwestern Ethiopia.

Figure 3.10. 1: Avocado oil processing in Sidama and Dila

The majority of avocado pressing facilities possess a large capacity, capable of processing between 50 to 60 tons of ripened fruit daily, provided that the necessary raw materials are accessible (Figure 3.10.2). Nevertheless, at present, all avocado processing enterprises are facing a shortage of fresh fruit, preventing them from operating at full capacity.

Figure 3.10. 2: Avocado fruits prepared for ripening in avocado oil processing plant

3.10.2. Bottlenecks of avocado-processing companies

A growing number of companies are showing interest in the production of avocado oil in Ethiopia. However, there is a pressing issue regarding market linkages among the avocado producer Primary Cooperative Association, unions, traders, and oil manufacturing facilities that requires urgent resolution. If improvements are made within the national Primary Cooperative Association and unions, along with the implementation of contractual farming, it is anticipated that the number of avocado oil factories in Ethiopia will rise, ultimately benefiting farmers, all participants in the value chain, and the country's economy as a whole. There are various bottlenecks currently affecting avocado oil production facilities in Ethiopia, which have resulted in insufficient production levels. Some of these challenges are outlined below.

Lack of suitable varieties with high oil content- Almost all avocado trees in Sidama and southwestern Ethiopia are sourced from local avocado types, which probably yield lower amounts of fresh fruit and oil annually. Therefore, it is important to facilitate the growth of commercial cultivars to ensure that all parties along the avocado value chain can benefit.

The current avocado trees in existence are predominantly low-yielding, heterogeneous local varieties that suffer from inadequate field management practices. Numerous avocado oil processors have reported that these local varieties exhibit low oil content, although this has yet to be confirmed. Conversely, while the Hass variety is recognized as suitable, its high market price renders it unaffordable for oil processors. A national strategy is necessary to replace these aging trees with high-quality avocado varieties that possess significant oil content. Furthermore, substandard harvesting techniques, such as the collection of immature fruits and improper handling that leads to damage, cracking, and bruising, adversely impact the oil yield of the processed avocado fruits and need to be addressed. High domestic consumption of fresh avocado fruits- Avocado consumption is notably prevalent in Sidama, South Ethiopia, as well as in South West Ethiopia, and Oromia. Moreover, there is a rising trend of utilizing avocados as fresh fruit in non-traditional areas, including Amhara, Tigray, Afar, and the Somali Regional States, posing competition to the oil processing and export sectors.

High level of rejection of low-grade fruits by the factories- A significant number of avocado fruits are discarded by oil extraction facilities as a result of inadequate harvesting and subsequent mishandling practices (Figure 3.10.2.1). To mitigate these losses, it is essential to enhance the capacity of Primary Cooperative Associations, Unions, and other private farmers who supply fruits to the factories. Furthermore, fostering dialogue among all stakeholders, including the industry, Primary Cooperatives and Unions, the Bureau of Agriculture, research institutions, universities, NGOs, and other relevant parties, is crucial.

Figure 3.10. 3: Rejected avocado fruits by the oil factories

Weak supply chain- Companies producing avocado oil are experiencing difficulties in securing fruit yields due to a range of supply chain complications. Most companies engaged in avocado oil production can process approximately 50 to 60 tons of avocado fruits each day. However, despite having formalized agreements through Memoranda of Understanding (MoUs) with cooperatives and unions for the procurement of graded fruits—namely Grade I, Grade II, and Grade III—the factories are not currently receiving the quality fruits as stipulated in these agreements. Additionally, traders in the supply chain often work with numerous brokers who purchase and gather quality fruits at prices that are comparable to or even lower than the farm gate prices offered by the companies for each kilogram of avocado. As a result, none of the companies can sustain continuous operations throughout the day and week. It is imperative to establish discussion platforms that engage all participants in the avocado fruit industry to streamline the procurement process and protect the interests of growers.

Higher level of free fatty acids- Normal values of free fatty acids are below 5% in most crude edible oils. Most free fatty acids are removed from crude edible oils during refining because of the undesirable effects on flavor, and the reduction of the smoke point caused by free fatty acids. Refined oil usually contains less than 0.1% free fatty acids (Chen et al., 2016). It has been reported that the local type of avocados utilized by the oil factories in the area possess higher concentrations of free fatty acids, unlike the Hass variety.

Low oil yield –The extractability and oil quality of avocado oil can be affected by factors such as fruit ripeness and pulp moisture and its corresponding dying method. Hydrolytic enzymes such as polygalacturonase and cellulases in avocado fruit degrade the parenchyma cell walls during ripening. As a result, the cell tissue is softened and more paths are created for the solvent to access the parenchyma cells (Mostert *et al*., 2007).

It has been reported by all factories that the current yield of avocado oil is alarmingly low, requiring an estimated 50 to 60 kilograms of ripe avocados to produce a single liter of crude avocado oil. This yield is significantly below expectations, as a minimum yield of 6% is sought

for avocado oil manufacturing facilities. There is a pressing need for further research to optimize the yield of avocado oil.

Low fruit quality- Avocado fruits sourced from farmers are frequently plagued by a range of defects that cannot be adequately addressed at the collection center. The defects observed include wounds, scratches, bleaching, squashing, punctures, shrinkage, compression, lesions, crashes, and others. Such imperfections ultimately lead to the spoilage of the fruits during the ripening process in factories. Furthermore, some of these issues are associated with increased free fatty acid content in crude oil. Issues related to fruit quality arise during the harvesting process, compounded by inadequate handling practices in subsequent stages.

Observations made during the survey indicated a considerable volume of spoiled avocado fruits after they underwent ripening in the ripening room. Reports suggest that a minimum of 2% to 20% of the avocados procured by the company are lost during the ripening phase at ambient temperature due to decay. After the healthy fruits are identified and separated, the leftover rotten avocados are deemed worthless and are disposed of immediately. This situation highlights that the factories are receiving inferior-quality avocado fruits, and the suppliers are failing to meet the harvesting and handling protocols required by the factories.

Lack of farmland for avocado production by Factory Owners- Avocado oil-producing companies have reported that obtaining farmland is fraught with difficulties. These challenges are attributed to extensive procedural requirements, differing priorities among management officials, and the specific investment dynamics present in various regions.

Absence of duty-free privilege for material costs, equipment, and accessories- Many factories involved in avocado oil production assert that they require duty-free access to various accessories, spare parts, and machinery necessary for their operations.

Organizational Problems -Avocado producers in the Sidama Region and Gedeo Zone of Southern Ethiopia have formed Primary Cooperatives and Unions to supply fresh avocado fruits to oil production facilities. The Yoya Avocado Union, located in Gedeo, consists of 15 Primary Avocado Growers Cooperatives and provides avocado fruits to the SEIZ Plc. Avocado Oil Processing Plant in Dilla IAIP. Likewise, avocado growers across various zones in the Sidama Region have established Primary Cooperatives and Unions to supply fruits to IAIP factories in Yirgalem. However, there is a lack of effective implementation of the Memorandum of Understanding (MoU) among all Unions, Primary Associations, and oil-producing factories, leading to mistrust between the factories and the Primary Avocado Growers Cooperatives/Unions. This situation reflects deficiencies in the operational framework of cooperative laws. Therefore, it is essential to ensure the effective implementation of the MoU and to facilitate effective communication among the involved parties. Additionally, the Federal Cooperative Commission and Regional Cooperative Agencies exhibit limited engagement, and there is a failure to consistently apply the laws governing Primary Cooperative Associations, which further hampers negotiations aimed at resolving disputes. The constraints that significantly impact the supply of avocados to oil processing plants are discussed as follows.

Cooperatives experience a number of obstacles in their efforts to supply avocados to the oil processors, which include:

Shortage of standard commercial avocado seedlings- The growing and management of improved avocado seedlings, which are meant to provide avocados to industrial parks and foreign markets, are currently inadequate.

Maturity determination-Presently, avocado producers face challenges in accurately determining the maturity of various local avocado varieties. The continuous maturation and harvesting activities, which occur throughout much of the year, add to the complexity of establishing exact harvesting timelines. It is essential to conduct research that helps in the identification of maturity in local avocado varieties in every region of Ethiopia (Suljada, 2024).

Limited capital- The lack of adequate capital among the Primary Cooperatives and Unions poses a barrier to the collection of fresh avocado fruits from member associations. This funding is necessary for the purchase of various small items, including crates, packaging materials, and transportation facilities.

Shortages of logistics and weak coordination- There is an evident shortfall in the logistics needed for the collection, storage, and transportation of avocados among the members of the cooperative association and the Union. Additionally, the Cooperative Association and the Union are functioning without adequate coordination

Lack of refrigerator truck -The members of the cooperative association and the Union lack a truck that is equipped with a refrigerator for the storage and transportation of produce

Lack of avocado harvesting equipment-All farmers growing taller local avocados in all surveyed areas lack harvesting equipment and tools

Limited knowledge of farmers towards producing high-quality fruits and supply to factories- It is expected that every avocado oil processing plant will have a collection center close by. However, the majority of farmers in the vicinity of the factories indicated that the factories source avocado fruits from distant locations, while local farmers are selling their avocados in nearby markets.

Cross-contamination of avocado fruits- There is a substantial probability that the chemicals utilized for managing other crops and intercrops could be found in avocado oil. Moreover, any chemicals that are employed or transported for different purposes in trucks may also compromise the quality of avocado oil in the market. Evidence has shown that certain agricultural chemicals were present in fresh avocado fruits exported from Ethiopia.

Poor marketing system- Avocado fruits are often sold at low prices at the farm level and Primary Avocado Growers Cooperatives. The Union engages in price negotiations and establishes a bilateral joint contract with the avocado processing factories, ensuring mutual benefits for both parties involved in the agreement. While there are three classifications established in the agreements between factories and unions representing primary cooperatives, these classifications lack a definitive boundary that facilitates conflict resolution as understood by laws and regulations. It is essential to develop clear descriptions of the quality associated with these fruit grades, as such descriptions will aid both existing and contractual farming practices governed by legal frameworks.

Local trader dominance-Traders rely on numerous brokers who gather high-quality avocado fruits on their behalf. Oil processors acquire the remaining lower-quality avocados, which, after ripening in their facilities, often result in a significant number of rotten fruits due to various factors. Illegal traders and transporters purchase first and second-grade avocados at reduced

prices established by cooperatives, unions, and factories. This practice has led to a shortage of quality avocado supplies for factories, compelling them to buy lower-grade fruits.

3.11: Mapping of Avocado Development Supporting Organizations, Strategies, Policies and Guidelines

The development of the avocado sector requires both horizontal and vertical support. In Ethiopia, there exists a range of supporting functions and regulatory bodies as detailed below.

3.11.1. Supporting functions (Institutions)

There exists a multitude of organizations that support the development of avocados. Among these are input suppliers, and the Ministry of Agriculture (MoA) and Bureaus of Agriculture (BoA), which provide extension services through development agents.

In addition, credit and financial service providers, packhouse and storage facilities, transportation services, and training and skills development organizations are involved. Research organizations, universities, and Agricultural Technical and Vocational Education and Training (ATVET) institutions, including various agricultural colleges in Ethiopia, as well as non-governmental organizations (NGOs), also play a vital role in this sector.

At present, numerous non-governmental organizations (NGOs) are actively involved in the advancement of the avocado industry in Ethiopia. Notable among these organizations are SNV, GIZ, TechnoServe, SAA, and ATI, which are contributing significantly to various aspects of avocado development.

The Ethiopian Trading Businesses Corporation, through its Fruit and Vegetable Trading Business Unit (EVTBU), engages in the procurement and sale of a diverse range of fruits, vegetables, vegetable seeds, and processed agricultural goods. This initiative primarily aims to stabilize the domestic market while also facilitating the export of fruits and vegetables to international markets.

MoTRI is tasked with the critical function of ensuring the quality of goods that are imported and exported, which are necessary for the development of the avocado industry. This quality assurance process includes the assessment of imported items that contribute to the avocado value chain in Ethiopia. The range of items evaluated consists of nursery tools (grafting tools), farming equipment (such as sprayers and pumps), agro-chemicals (including pesticides, fertilizers, and herbicides), harvesting tools (like crates and bins), various packaging solutions (such as plastic packages, wooden boxes, cartons, bags, corrugated fiberboard boxes, pallets, and automatic sorting and grading machines), as well as cold storage options, packhouses, refrigerators, and refrigerated tracks, as well as items required for avocado oil processing- avocado cold press machines, spare parts, oil packaging materials and other required items.

Moreover, MoTRI, along with its regional branches, the Regional Bureau of Trade, and Zonal and Woreda offices, is responsible for issuing licenses to operators of avocado nurseries, traders, wholesalers, retailers, and transporters. However, there exists a lack of coordination among the Regional Bureau of Trade, the Ethiopian Agricultural Authority (EAA), and the Ministry of Health (MoH) regarding the maintenance of high standards for avocado seedling quality and fruit food safety. Quality control measures for avocado seedlings are likely to be inadequately managed by the EAA and the regional agriculture and input control under the Bureau of Agriculture (BoA). Furthermore, there is insufficient oversight of food safety for fruits

throughout the supply chain, resulting in the presence of rotten fruits mixed with healthy ones in various cities and towns across Ethiopia.

There is a clear absence of coordination between the Regional Board of Trade (BoT) and the Ministry of Health (MoH) regarding the licensing of fresh avocado fruit traders, particularly concerning food hygiene and consumer safety. The Ministry of Trade and Regional Integration (MoTRI), along with the Regional BoT, focuses solely on tax collection and revenue generation, neglecting the quality control of fresh fruits and the health of avocado consumers in Ethiopia. It is common to find spoiled fruits, including those with mold and partially rotten produce, in various fruit and vegetable shops across the country. Traders often sell these contaminated fruits at reduced prices to economically disadvantaged individuals, and other users.

3.11.2. Supporting policies, guidelines, and strategies for avocado industry development

A variety of national support policies, guidelines, and strategies are in place to facilitate the growth of the avocado sector in Ethiopia. Some of these include:

National Avocado Development Program (NADP)- The previous National Avocado Initiative has now been enhanced to the National Avocado Development Program (NADP) in Ethiopia, with avocado being one of the ten selected commodities for the national development strategy (MoA, 2021). A feasibility study for national avocado production is currently in progress.

The earlier National Avocado Initiative is currently upgraded to the NADP in Ethiopia and avocado is one of the 10 in 10 selected commodities for the national development plan (MoA, 2021). Currently study of national avocado feasibility is underway and the report validation is expected in September 2024.

National Horticulture Policy, National Horticulture Roadmap and Strategy-The National Horticulture Strategy's 10-year development plan has been officially validated (MoA, 2024b). This strategy seeks to address the key challenges that limit Ethiopia's competitiveness in the international horticulture market. It is expected to be vital in unlocking the complete potential of avocado cultivation. The implementation of this strategy will involve a diverse array of stakeholders, including the Ethiopian Horticulture Producers and Exporters Association (EHPEA), the Ministry of Agriculture (MoA), the National and Regional Research Systems, the Agricultural Transformation Institute (ATI), NGOs, agricultural universities, and private producers and exporters.

National Postharvest strategy-The Ministry of Agriculture (MoA) has introduced the National Post-Harvest Management Strategy for the period 2024 to 2030 (2016-2022 E.C.). The strategy serves as a practical framework aimed at decreasing both the quantitative and qualitative losses of food by promoting the adoption and execution of suitable post-harvest management practices for agricultural products.

3.11.3. Cold chain infrastructure development

Modjo cold chain infrastructure development- The development of a comprehensive cold chain infrastructure in Modjo is currently in progress. This facility, which represents a full cold chain package, is linked to both the Ethiopian Railway and sea freight shipping, ensuring that all fresh fruit and vegetable products from Ethiopia can be exported through these facilities. Moreover, cold chain logistics facilities are situated at the Addis-Modjo location, managed by the Ministry

of Transport and Logistics (MoTL), thereby enhancing the export process for fresh avocado fruits.

3.12. Opportunities for accessing Technologies, Information, and Management Practices (TIMPs) to Reduce Avocado Postharvest Losses

The major factors leading to substantial postharvest losses include poor pre- and post-harvest handling practices, inefficient marketing systems, limited investment in research and development, inadequacies in infrastructure, and the flow of information. The subsequent discussion will highlight a range of opportunities concerning the availability of TIMPs.

3.12.1. Availability of commercial avocado varieties

Commercial avocado varieties are cultivated in various parts of the country, including East Shewa, North Gojjam, and Silte. On the other hand, local avocado seedlings are prevalent in the high-rainfall regions of Ethiopia. Areas like Kaffa, Jimma, Illuababora, Konta, and the humid regions of Sidama, Gedeo, Wolaita, Gamo (Kamba), and Gofa (Basketo), as well as South and North Bench, are notable for their local avocado trees. These regions possess significant potential for the introduction of many new varieties resembling the Hass variety, should a vigorous selection program be undertaken (Figure 3.12.1 and Figure 3.12.2).

Figure 3.12. 1: Avocado fruits from local trees (Cheta Woreda, Kaffa Zone)

Figure 3.12.1. 1: Potential local avocado types from local materials

3.12.2. Availability of avocado nursery operators' techniques and guidelines

At present, the country has three to four nurseries dedicated to avocado cultivation. With the introduction of new guidelines for nursery accreditation and seedling certification, there exists a significant potential to supply a substantial number of high-quality grafted avocado seedlings each year. The Ethiopian Agriculture Authority, in collaboration with the relevant Regional Input Authorities, is tasked with ensuring the maintenance of high-quality avocado seedlings.

3.12.3. Availability of avocado development supporting non-state actors

A variety of non-governmental organizations are engaged in the promotion of fruit development, including avocados. Key players in this field include ATI, SNV, USAID, GIZ, and others.

3.12.4. Existence of Avocado production guide

Guidelines for the production of avocados are established and regularly updated each year by the Ministry of Agriculture.

3.12.5. Availability of Avocado fruit harvesting tools

Various fruit harvesters have been developed and tested in the country (Figure 3.12.2) by different organizations (Alemayehu *et al*., 2024) and NGOs. Along with the use of fruit harvesters, the process of selective fruit harvesting is crucial for the effective handling of avocado fruits. It begins with the careful selection of fruits during the harvesting phase, followed by appropriate postharvest management to ensure the freshness of the fruits until they reach consumers. Techniques for selective harvesting involve the use of bags secured to the harvester's chest, allowing the harvester to grasp the fruits with their left hand, equipped with a glove while using their right hand to operate secateurs. The harvester then cuts the physiologically mature fruits along with their stalks and gently places them into crates.

Figure 3.12. 2: Simple avocado fruit harvesting tools

3.12.6. Existence of packaging facilities in Et-fruit

Currently, the Fruit and Vegetables Trading Business Unit is one of the Ethiopian Trading Businesses Corporation, Established in 2015, under the Supervising Authority of the Ministry of Trade, Federal Government Public Enterprise. The then-Ethiopian fruit and vegetable marketing share company (Et-Fruit) was pioneered in 1980, as the Horticultural Development Corporation (HDC) to function as a marketing body for entirely state-held horticulture farms (Tesfaye, 2015) which was restructured in 1993 in harmony with the provision of the public enterprise. The range

of its service provision has since then expanded to comprise private horticultural farmers striving to move into the export market. Et-Fruit can be labeled as a leading and major national distributor and exporter of fresh vegetables and fruits including avocado, and processed horticultural products (Ethiopian Business Directory, 2024). The marketing chain facilities of Et-Fruit have progressed to a better status of development in the last three decades due to its better market network and associated facilities compared with other wholesalers.

Figure 3.12. 3: Big field harvesting bins used for fruit harvesting

Figure 3.12. 4: Field harvesting of avocado fruits with plastic crates for transportation

3.12.7. Availability of private trucks with refrigerator facilities

Besides Et-fruit, there are many private companies providing services for fruit harvesting bins and crates, as well as trucks with refrigerators in Ethiopia (Figure 3.12.5) and EHPEA is facilitating high-standard postharvest handling in Ethiopia. Currently, there exists a considerable fleet of private trucks with refrigeration capabilities that are involved in the horticulture development sector. If private packhouses and wholesalers were to create a platform, these facilities could deliver their services in alignment with agreed-upon terms.

Figure 3.12. 5: Refrigerated trucks and cargo logistics available from Et-fruit

3.12.8. Modest experience in sorting, cleaning, grading, and packaging activities

Currently, avocado exporters in Ethiopia are undertaking all necessary steps to comply with the export requirements for the European Union and Arab nations, Figures 3.12.6 and 3.12.7). The trends of urbanization and rising income levels are expected to drive an increase in avocado demand within Ethiopia, thereby presenting opportunities for value addition, such as the development of superior quality and a wider range of products. Additionally, there exists considerable potential for the country to expand its domestic and export markets, as well as to enhance product value through methods like juice processing and oil extraction.

Figure 3.12. 6: Fresh avocado fruits ready for grading and sorting

Figure 3.12. 7: Prepackaging materials and packaging operations (Koka Ethio Veg)

3.12.9. Shelf-life extending opportunities

To extend the shelf life of avocados before they ripen, they are treated with an edible coating for storage at room temperature, subjected to cold shock treatment, and stored at low temperatures (EHPEA, 2014e). These practices are carried out in packhouse operations after the grading of Hass fruits, as detailed in EHPEA, 2014a-g and UN, 2017 (Table 3.12.8.1).

In all sampled zones and regions, the management of Hass avocado production was found to be insufficient, resulting in a considerable percentage of exported fruits being notably small. This observation points to an absence of adequate nutrient application, both in terms of the necessary amounts and the timing required by the avocado plants. Similarly, the small fruit sizes reflect a lack of proper irrigation water supplied to the Hass avocado fields during the production years. Moreover, this inadequate management of the fields suggests that the lifespan of avocado orchards in this region may be limited in the future.

Table 3.12. 1: Fruit sizes of exported Hass avocado from the sample woredas

No of Pcs/Box	Gram /fruit	Total Pcs	Percentage
12	306-365	876	1
14	266-305	3,766	6
16	236-265	8,032	13
18	211-235	13,770	22
20	191-210	14,180	23
22	171-190	17,446	28
24	≤170	4,704	7
Grand total		62,774	100

3.12.10. Information on packaging and transportation and Global GAP guidelines

Various guidelines for the development of postharvest management capacity for fruits and vegetables have been established by EHPEA (EHPEA, 2014 a,b,c), which significantly improve the postharvest management of avocados. From the moment of harvesting, all avocado producers should utilize plastic crates throughout the entire supply chain until the products reach retail outlets. This postharvest handling and management of avocados should be reinforced by the national postharvest policy and strategy implemented by the relevant institutions in Ethiopia. Avocado farmers need to receive training in harvesting techniques and the assessment of fruit maturity, as well as in all subsequent postharvest handling practices.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The study was carried out across six prominent avocado-producing regional states of Ethiopia: Amhara, Oromia, Sidama, South Ethiopia, Central Ethiopia, and South West Ethiopia. Its primary aim was to assess the postharvest losses of avocados, while also examining the entire avocado value chain. A range of methodologies was utilized, including field surveys, loss measurement via load-tracking methods, and the analysis of secondary data.

The study thoroughly examined various aspects of avocado production, including pre-harvest management practices that affect postharvest loss (PHL), as well as avocado harvesting and postharvest handling practices along the supply chain. It also looked into avocado export and processing, determined qualitative and quantitative fruit losses and critical loss points, and estimated the impact of avocado losses on the economy, nutrition, and the environment. Based on these findings, the study recommended technical and technological innovations to help mitigate postharvest losses.

The study found that several agronomic and tree management pre-harvest practices influence avocado postharvest loss (PHL). Overall smallholder avocado growers under all production systems predominantly use traditional orchard management and postharvest handling practices and methods. Improved avocado harvesting and postharvest handling practices are rarely practiced at smallholder farmers' level and across the supply chain. Institutional support for

avocado development is primarily focused on the supply of grafted seedlings and the provision of training on orchard management with little emphasis on PH management and the availability of improved harvesting and handling materials and tools. Except for produce destined for the export market, cleaning, cooling, grading, packaging, labeling, and controlled environment transportation are rarely practiced.

Specifically, the use of avocado seedlings grown from seed (ungrafted seedlings) has a substantial impact on overall avocado production and postharvest losses. Avocado orchards in study areas are generally classed as seedling seed or clonal seed orchards. Farmers who mostly use avocados Seedling Seed Orchards are primarily found in the traditional avocado-growing regions of southwestern and southern Ethiopia, including Jimma, Kaffa, Teppi, Wolaita, and Sidama. In these areas, avocados are primarily grown on rainfed systems, which results in less synchronized and controlled fruit maturity and harvesting, as well as non-uniform fruit attributes. These avocados are frequently planted using seeds derived from the crossing of natural populations of several avocado races and classes with varying morpho-agronomic characteristics. This heterogeneity has an impact on post-harvest qualities such as quality retention, regularity in maturity and ripening, fruit size, color, shape, taste and flavor, and oil content. Furthermore, the excessively tall plants with uncontrolled branching make harvesting difficult, resulting in fruit damage and skin bruising, and inappropriate harvesting procedures expose fruits to infection from post-harvest diseases and hygienic issues. Farmers in these areas continue to practice traditional orchard management and post-harvest handling methods, contributing to the challenges in maintaining fruit quality and minimizing post-harvest losses.

On the other hand, farmers who own Clonal Seed Orchards are predominantly located in newly established plantations for commercial avocado production in areas such as North Mecha, Silte, and East Shewa. These orchards are primarily irrigated, leading to relatively controlled fruit maturity and harvesting, though there are instances of irrigation water shortage that affect fruit growth and development, impacting post-harvest quality. These orchards are planted with grafted seedlings of the commercial varieties predominantly Hass and its pollinators. The trees in these orchards are dwarf and easy to harvest, with the Hass variety offering excellent keeping quality and uniform maturity. Farmers in these regions generally employ better orchard management and post-harvest handling practices. However, these orchards are more vulnerable to seedling-derived pests due to less regulated seedling production and multiplication.

The harvesting of avocados especially in non-commercial growing areas is done traditionally, with people climbing tall trees or using long poles to drop fruits, resulting in breakage, bruising, contamination, and spoilage of fruits.

Harvested produce is handled in plastic sacks and transported to collection points, aggregation centers, or local markets by pack animals or animal-drawn carts, and trucks are rarely used where production areas have road access. Smallholder avocado producers do not use wooden or plastic crates. Avocados are bulked and loaded into ordinary vehicles and driven to distant

markets. Both long-distance and short-distance handling and transportation methods aggravate loss and are unhygienic. Legislative and regulatory entities do not regulate value chain actors and encourage investment in logistics (specialized transport, storage, handling, and marketing). As a result, the local fresh fruit market is monopolized by 'cartel' like actors who add little value but exploit the highly perishable nature of avocado fruits and the vulnerable logistical capacity.

According to the study, 13.4% of fresh avocado fruits produced are consumed at home, 72.3% are supplied to the domestic fresh fruit market, 11% to the export market, and 2.4% to domestic processing factories. Avocado growers are disorganized, making it difficult to negotiate prices and contracts. They frequently fail to meet market quality and quantity standards and have little control over price, leading to unfair practices. As a result, wholesalers dominate the market with a 32.0% market margin and a 39.6% profit margin, while producers have a 12.8% market margin and a 7.5% profit margin.

While avocado produce destined for the export market is sorted and graded in accordance with export standards, no standard exists for locally marketed avocado fruits. As a result, traders impose arbitrary norms and implement sorting and grading across the supply chain. Furthermore, there is intense competition between the avocado fresh market and domestic processing companies. Consequently, the majority of the avocado processing plants operate under capacity due to supply shortfall and other problems.

Using survey and load-tracking methods, the study estimated an average avocado loss of 41%. This figure is broken down into 39% in the survey method (with quantitative post-harvest loss at 23.46% and qualitative post-harvest loss at 15.53%), and 43.2% in the load-tracking method (with quantitative loss at 24.5% and qualitative loss at 18.7%). The critical loss points in the supply chains where the most significant losses occur, impacting both the quantity and quality of avocados available to consumers, are identified at the retail market (12.5%), wholesaler storage and marketing (11.2%), and harvesting (8.9%), in that order.

Finally, the total economic loss due to avocado harvest/postharvest loss is estimated at 5,129,760,540 birr. The annual avocado loss could have met the food energy needs of 61,431 adults, provided protein for 2,399,639 adults, and met the carbohydrate needs of 5,316 adults; the loss of avocados could have met the folate, potassium, and magnesium needs of 194,371 adults, 133,009 adults, and 66,276 adults, respectively. It also causes an estimated loss of 249.16 billion kilocalories of dietary energy. Moreover, it renders 7,494 hectares of land unproductive annually. In addition, a loss of 63,669.5 tons of avocados is expected to generate 159,249 tons of CO_2 emissions.

4.2 Recommendations

The Ethiopian government has devised and adopted a post-harvest management strategy to reduce PHL in grain, fruits, vegetables, livestock, and fish. Implementation of such a comprehensive plan necessitates commodity-specific interventions based on practical evidence. As a result, this study has generated baseline information on avocado PHL, which can be used to set targets, implement strategies, and track reduction over time. To reduce avocado postharvest loss and enhance economic, social, and environmental benefits the following technical, technological, and institutional solutions are recommended.

1. **Enhance the Knowledge and Skills of avocado growers and other value chain actors:** Improve smallholder avocado growers', extension agents', collectors and aggregators, transporters, wholesalers, and retailers awareness and knowledge, and promote technical innovations in production and post-harvest management methods and technologies that reduce PHL at critical levels of the supply chain.
2. **Develop Capacity Along the Avocado Value Chain**: Strengthen the capacities of all stakeholders involved in the avocado supply chain, from farmers to exporters.
    - Improve smallholder farmers' access to improved harvesting tools, including scissors and attached handling bags. Such materials help in the proper harvesting of avocado fruits with stem end stalks intact, minimizing mechanical damage during harvesting as well as exposure to dirt and microbial contamination from falling avocados. These materials have a simple design and can be produced locally at a lower cost than imported counterparts.
    - Provide improved access to collectors, aggregators, transporters, wholesalers, and retailers with post-harvest handling materials such as plastic boxes and appropriate packaging products. Providing these stakeholders with the necessary tools and materials will help maintain the quality of avocados throughout the supply chain, ultimately reducing post-harvest losses and improving marketability. By investing in these improvements, the entire avocado value chain can benefit, leading to better economic outcomes for all involved.

3. **Invest on Avocado Infrastructure**: By ensuring that avocados are transported in optimal conditions, it is possible to drastically reduce post-harvest losses and provide consumers with fresh, high-quality produce.
    - Promote private-public partnerships to invest in logistics and infrastructure capacity, including transportation, storage, and marketing. Investments in refrigerated/controlled atmosphere trucks for avocado fruits and horticulture products in general are required, just as they are in other sectors, such as dumb trucks (construction, urban waste), tanker trucks (fuels, dangerous liquid chemicals, gases, liquid wastes), semi-trailer trucks (dry cargos), and flatbed trucks (vehicles and machinery).
4. **Invest in Research & Extension and Technology Development**: Invest in research and Extension to identify and address key challenges facing avocado production and post-harvest handling and promotion of improved technologies and practices.
    - The Research system needs to develop/ adapt alternative varieties with high yield and better postharvest qualities to reduce PHL, and biological and market risks associated with relying on a single clonal variety, Hass.
    - Generate/ adapt knowledge to address local pests, diseases, nutrient deficiencies, and disorders that induce post-harvest loss.
    - Establish clonal seedling orchards by scaling up clonal propagation of high-yielding avocado varieties with superior postharvest quality.
    - Establish maturity indices for various avocado varieties in clonal orchards and provide access to non-destructive tools.
    - Develop strategies to ensure a reliable supply of irrigation water, especially in regions with frequent water shortages, to support consistent fruit growth and quality.

- Promote the use of improved agricultural technologies, such as clonal propagation and controlled irrigation systems, to improve fruit quality and yield.
- Conduct demonstrations of effective orchard management and post-harvest handling techniques to showcase their benefits and encourage widespread adoption.
- Identify the start and end of the flowering season, other phenological growth stages, and exact maturity dates of avocado fruit varieties in each major agroecology.
- As avocado production increases, its utilization is expected to rise. Therefore, nutrition needs to be promoted, especially among women.

5. **Promote Market Linkages**: Establish stronger market linkages between farmers and buyers, including both domestic and international markets, to improve market access and ensure fair pricing.
6. **Empower women in Avocado Value chains**: Women play a crucial role in avocado production, and their participation can lead to numerous benefits for families and communities. Given the potential for avocado production to provide a steady income, particularly in traditional growing areas where fruits are harvested asynchronously multiple times a year, empowering women can contribute significantly to economic generation and food security.
7. **Establish a Robust Quality Control Mechanism**: Implement stringent quality control measures at various stages of the value chain to ensure that only high-quality fruits reach the market.
   - Develop and enforce nursery and nursery product standards to ensure a consistent supply of healthy, true-to-type clonal seedlings of recommended varieties.
   - Establish standards and grading systems for avocado fresh fruits in the export, domestic, and processing markets that align with worldwide standards such as Codex Alimentarius.
   - Review or establish commodity-specific legislative frameworks to encourage avocado fresh fruit supply chain actors to adopt science-based practices and invest in at least primary value-added technologies such as sorting, cleaning, grading, packaging/handling, transport/storage logistics to reduce loss, improve quality and food safety, and enhance social, environmental, and economic benefits.
   - Establish fiscal measures such as tax legislation, to disincentivize acts that contribute to PHL and promote actions that reduce PHL across the supply chain. Disincentives may include levying landfill taxes on discarded produce or tax deductions for investments in primary value additions that mitigate PHL.
8. **Improve Coordination and Collaboration**: Foster better coordination and collaboration among institutions to ensure complementary efforts to support the avocado value chain and PHL prevention and reduction actions. This includes coordination among governmental organizations such as agricultural research and extension, regulatory bodies (agriculture authority, Standards Services, Food and Drugs Control Authority), trade and market development, Industry/ agro Industry, Customs and Revenue, Transport and Logistics etc.); non-governmental organizations, private value chain actors, the finance sector, farmers organizations, donors/ development partners, and others.

9. **Ensure Equitable Profit Margin Share:** The largest share (39.6 %) of the profit margin goes to wholesalers and the avocado growers gain only 7.5% of the profit. The highly perishable nature of the crop is making farmers more vulnerable to the observed price distortion. Unless timely fixed, such practices will, in the long run, challenge sustainability of avocado production and other value chain activities in the country. Further, the unfair price control and exploitative business practices can affect the consumer and more importantly the low-income segment by denying them the right to safe and nutritious food. Hence, policies that promote equitable distribution of profit margins among all value chain participants might need to be considered.

The aforementioned recommendations are believed to address the critical points of loss in the avocado value chain and improve overall efficiency, benefiting producers, intermediaries, and consumers.

4.2.1. Proposed matrix of key stakeholders and action areas to mitigate avocado PHL

Postharvest losses are prevalent at various stages of the supply chain; however, the capacity-building programs implemented by the Ministry of Agriculture (MoA) and Regional Bureaus of Agriculture (RBoAs) have predominantly focused on training farmers and experts. Unfortunately, these initiatives have not addressed the training needs of other critical supply chain stakeholders, such as collectors, aggregators, transporters, traders, wholesalers, and retailers, who play significant roles in harvesting and postharvest management.

To effectively mitigate the quantitative loss in avocado fruits and to uphold the standards of harvest quality, action areas and responsible key stakeholders are proposed. All development partners associated with the avocado supply chain need to fulfill their respective roles, ensuring that organizations complement one another effectively.

Table 4.2. 1: Key institutions and actions required for harvesting and postharvest handling

Stakeholders	Actions that need to be taken
Farmer's level	1. Hand-picking fruits from short trees with bags
	2. Harvesting only matured fruits using harvesting sticks with bags; avoiding harvesting immature fruits
	3. Putting gloves on left hand for holding fruits, and wielding secateurs with right hand for cutting fruits
	4. Cutting fruit stalks approximately 3 cm above the fruits and putting either in a bag or in crates
	5. Not filling the crates since one crate is placed over the other; careful handling during harvesting; avoiding letting the fruits touch the ground
	6. Avoid piling/ overflowing avocado fruits on the ground at home and the local/main markets
	7. Use of crates (plastic and wooden), by farmers, and aggregators, across all supply chain stages
	8. Avoiding using polypropylene bags, stacking fruits together at producers' levels and all subsequent supply chain stages
	9. Harvesting in the morning and late afternoon

Stakeholders	Actions that need to be taken
	10. Avoiding harvesting fruits while it is raining
	11. Rapid delivery of fruits to the aggregation centers
BoA/ ATI/ GIZ/SNV/SAA	12. Support replacement of old, un-grafted tall trees with shorter varieties to facilitate the harvesting of avocados; provision of adequate knowledge on tree establishment, irrigation, nutrient management, crop protection, and other important practices
MoA	13. Facilitate implementation of national fruits and vegetables post-harvest strategy, national horticulture policy and strategy, NADP, etc. at the national and regional levels.
Federal / Regional Research System	14. Develop improved production technologies such as alternative new varieties and field management practices
	15. Develop improved PH technologies and improved fruits handling practices
Aggregation centers/ traders	16. Avoid piling/ overflowing avocado fruits on the ground in the aggregation center
	17. Introducing simple solar cooling systems
Traders/ transporters	18. Avoiding piling/ overflowing avocado fruits on the ground at the local/ main market center
Packhouse service providers	21. Use of value addition at aggregation centers, use of simple packaging at key production centers; use of pack house
Minisltry of Transport and Logistics	22. Prohibiting transporting bulked avocado fruits using ISUZU/ FSR trucks
	23. Force all traders to use crates and load a maximum of 35000 kg per ISUZU truck rather than 60000 kg per transportation as practiced at present
	24. Use of refrigerated trucks/ for temperature and RH control along all avocado supply chain stages
	25. Regulation of fresh avocado fruits transported in an unstructured manner, which could result in possible contamination
Ministry of Trade and Regional Integration (MoTRI)/ BoT	26. Establish minimum criteria for obtaining a marketing and trade license for fruits across all supply chains.
	27. Minimizing handling of produce in storage and distribution systems, by integrating the supply chain approach and appropriate sequencing in the development of infrastructure that will ensure shorter supply chains, with fewer intermediaries.
	28. Investigating the potential (market and viability) of **value-added processing** in the avocado chains by specialized processing enterprises, as well as **quality improvement** through improved handling and ripening.
	29. Market development for diversified and value-added avocado products, coupled with improvements in avocado quality, and the promotion of the consumption of these products
Federal Cooperative Commission	30. Introduce, improve, and expand technology, infrastructure, and equipment, at trader and wholesale levels, as these sectors offer considerably more potential than at the farm level; especially market facilities for fresh produce, ripening, and cold chains.

Stakeholders	Actions that need to be taken
	33. Mobilizing farmers in each locality to form marketing organizations at a national level through which traders, avocado oil processors, etc. can directly access their produce.
Regional Bureaus of Cooperative Agency	34. Mobilizing of farmers in each locality and region to form marketing organizations through which traders and avocado oil processors can directly access their produce, market centers,
	35. Constructing and establishing fruits central packhouses in the major production areas along the implementation modality
	36. Constructing and establishing fruits central marketplaces in the major cities and towns of Ethiopia where
	consumption is high
	37. Strengthening primary avocado growers' cooperatives/ unions, so that they get negotiation powers and enter contractual agreements with processors and other buyers
Ministry of Revenue	38. Development of guidelines for minimum costume tax for facilities, logistics, and infrastructure (crates, packhouse) for handling perishable agricultural goods
	39. Establish fiscal measures like tax legislation that disincentivize actions that contribute to PHL or incentivize actions that mitigate PHL across the supply chain.
Ministry of Industry	40. Investigate the potential (market and viability) of value-added processing in the avocado chains by specialized processing enterprises, as well as quality improvement through improved handling and ripening.
	41. Control the compliance of avocado fruits with the requirements of mandatory Ethiopian standards, and take measures against any non-compliance along the value chain; coordinate enforcement of standards applied by other enforcement bodies
	42. Expedite the acquisition of best practices, technology transfer and skills development, and general capacity-building activities in industrial development
	43. Establish systems of capacity building, research and inculcation to maintain quality standards and competitiveness of avocado oils, industrial products in international markets; oversee implementation of the strategy, including traditional market vendors.
Ministry of Health	44. Promoting the consumption of avocado and products
	45. Develop and introduce a postharvest pest/ disease management plan
	46. Safety assessments of the avocado supply chain based on the potential risk of avocado juice/ restaurants/ groceries and other products – consistent with modern preventive approaches to food safety regulation
	47. Provide a legal basis for the regulation of fruits /food packaging by considering potential hazards of poor-quality materials, including traditional market vendors.
Fruit & Vegetable Trading Business Unit/ Ethiopian Trading Businesses Corporation	48. Support and motivate avocado growers /farmers to raise their interest in producing avocado fruits and ensure that avocado fruit products get reliable market

Stakeholders	Actions that need to be taken
	49. Support production of avocado fruits, buy, distribute and maintain stock and sell to domestic and foreign markets through primary and secondary distributors (Addis Ababa) such as Afinchober, Akaki, and Samit with all Regional Branches/Trade Centers
	50. Rent cold chain logistics facilities
Consumer Products Trading Business Unit/ Ethiopian Trading Businesses Corporation	51. Purchase avocado commodities from local markets and distribute them through the retailers to meet local consumers' needs.
Ministry of Water, Irrigation and Energy (MoWIE)	52. Support large and medium-scale irrigation development for avocado production
	53. Ensure all commercial avocado growers and farms get sufficient irrigation water
Ethiopian Accreditation Services	**54. Accreditation of laboratories**, HACCP, MRL. Avocado HACCP is a management system in which avocado food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement, and handling, to manufacturing, distribution, and consumption of the finished product
Legislative bodies	55. Revise and develop commodity specific legislative frameworks that that require or encourage avocado fresh fruit supply chain actors adopt science-based practices and make adequate investments at least on primary value addition technical and technological innovations like sorting, cleaning, grading, packaging/ handling and transport and storage logistics across the supply chain to mitigate loss and improve quality and food safety issues and enhance social, environmental and economic gains from avocado development.
National monitoring mechanism	56. Establish a **monitoring mechanism**, to estimate avocado
	PH losses at any particular time, sampling of avocado traders at various stages along the supply chain, and taking account of their practices in the trade. In addition, a national monitoring mechanism for postharvest activities is crucial to oversee the implementation of the National Postharvest Strategy, the National Horticulture Strategy, the Ethiopia Food and Nutrition Policy, and other pertinent national policies and strategies across all levels.
	57. Facilitating the key national institutions take the lead: research, government, NGOs, and private entrepreneurs' partnership

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