

**TOMATO MARKET CHAIN AND POSTHARVEST LOSS IN ADEA  
DISTRICT, EAST SHEWA ZONE, OROMIA NATIONAL REGIONAL  
STATE, ETHIOPIA**

**MSc THESIS**

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SCIENCE IN AGRIBUSINESS AND VALUE CHAIN MANEGEMENT**

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We hereby certify that we have read and evaluated this Thesis prepared, under our guidance, by Hanna Tegegne Sishaw entitled “*Tomato Market Chain and Postharvest Loss in Adea District, East Shewa Zone, Oromia National Regional State, Ethiopia*”. We recommend that it be submitted as fulfilling the Thesis requirement for the Degree of Master of Science in Agriculture (Agribusiness and value chain management).

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## **DEDICATION**

I dedicated this work to my mother Ayehu Mesele and my father Dr. Tegegne Sishaw for their encouragement, support and patience during my studies.

## STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this Thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and completion of this thesis. Any scholarly matter that is included in the thesis has been given recognition through citation.

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## ACRONYMS AND ABBREVIATIONS

CIRAD	The French Agricultural Research Centre for International Development
CSA	Central Statistical Agency
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization of the United Nation
GDP	Gross Domestic Product
GM	Gross Margin
GMM	Gross Marketing Margin
MC	Marginal Cost
MR	Marginal Revenue
NBE	National Bank of Ethiopia
OLS	Ordinary Least Square
PLW	Postharvest Loss and Waste
PM	Profit Margin
R&D	Research and Development
SCM	Supply Chain Management
SCP	Structure Conduct Performance
SNNP	Southern Nations and Nationalities People
SSA	Sub-Saharan Africa
TGMM	Total Gross Marketing Margin

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# **Tomato Market Chain and Postharvest Loss in Adea District, East Shewa Zone, Oromia National Regional State, Ethiopia**

## **ABSTRACT**

*Postharvest loss poses a significant challenge to tomato producers and market chain actors in Adea district, necessitating a thorough assessment to identify areas for intervention. By employing a combination of primary data from 171 tomato-producing households and a sample of 32 traders including, 5 wholesalers, 14 retailers, 5 collectors and 8 consumers from two kebeles namely Godino and K'at'ila, along with both descriptive and econometric models, the study revealed critical insights. Results showed seven distinct market channels, with producers earning the highest profit when selling directly to wholesalers. The highest total gross marketing margin occurred in channels with multiple intermediaries. Postharvest loss averaged 47.02 quintals per hectare, with transportation being the leading cause (30.48%), followed by packaging, handling, storage, grading, and loading. Retailers experienced the highest losses (28.35%) due to frequent handling, poor packaging, and exposure to unsuitable conditions like heat and humidity. Collectors experienced moderate postharvest losses (12.76%), primarily resulting from inadequate packaging, transportation, and storage conditions. In contrast, wholesalers had the lowest losses (5.28%) due to better bulk handling and storage practices. Furthermore, robust multiple linear regression analysis identified explanatory variables such as credit, extension contact, insect pest infestations/rodents, farm size and distance to main road affected postharvest loss of tomato. By enhancing financial inclusion, training in postharvest management and handling techniques to reduce insect pest infestations and investing in infrastructure, policymakers can develop targeted interventions that substantially reduce losses, boost productivity and strengthen food security.*

**Key words:** *Gross marketing margin, Multiple linear regressions, Postharvest loss, Tomato*

# 1. INTRODUCTION

## 1.1. Background of the Study

World vegetable production has grown by 71% since 2000, reaching 1.17 billion tons in 2022. Tomato topped the list as the most produced vegetable at 186 million tons, followed by onions (111 million tons, including shallots), cucumbers (95 million tons, including gherkins), cabbage (73 million tons) and egg plants (59 million tons). The share of the top five vegetables doubled while that of cabbages remained stable (FAO, 2022). Globally, fruit and vegetable postharvest losses can reach as high as 50%, primarily occurring during harvesting, handling, storage, processing, distribution and consumption (Elik *et al.*, 2019).

In 2022, 85.6 million metric tons of vegetables in Africa were grown. Between 2018 and 2020, Africa's annual fresh tomato production was valued at approximately US\$6.9 billion at farm-gate price (FAO, 2023). During the same period, the continent exported \$0.9 billion in the form of fresh tomatoes all from Egypt, Morocco and Tunisia while importing around US\$0.6 billion worth of primarily processed tomato products (FAOSTAT, 2022). However, postharvest losses remained a significant challenge, with estimates from FAO indicating that up to 40% of fruits and vegetables are lost. These losses are primarily attributed to financial, managerial and technical constraints particularly in harvesting and handling techniques, as well as inadequate storage and cooling facilities (FAO, 2019).

Ethiopia is primarily dependent on agriculture, where the economy is largely driven by the agricultural sector. All other sectors, including exports and industrial processing also depend on agriculture (Getu and Almas, 2023). According to FAO's report (2024), Smallholder farmers in Ethiopia account for about 95% of the country's agricultural output dominating the agricultural sector and 85% of employment. This shows that small-scale agriculture is essential to the nation's overall economy and food security of the vast majority of its citizens. The share in agriculture GDP declined to 32.5% of which crop production has lion's share accounting for 65.1% followed by animal farming and hunting (26%) and forestry (8.6%) (NBE, 2021). The agricultural sector grew by 5.5% in 2020/21 compared to a 4.3% in

2018/19. According to NBE's report in 2021, the total amount of grain produced in 2020/21 was 341.8 million quintals with 2% annual increment.

According to CSA (2021), in Ethiopia, from the total area and production covered by all crops at national level, vegetable crop occupied 243,568 (1.62%) hectare of land and 9,067,870.78 (2.04%) quintal of production. Tomato covers 7.62% area coverage from vegetable land and total production of 21.94%. Despite Ethiopia's comparative advantage i.e. favorable climate, diverse altitude, high domestic demand, cheap labor, extensive land and water resource, the horticultural sector performance remains below its potential (Dube *et al.*, 2018). In relation to the predominant role played by the agricultural sector in Ethiopian economy, horticulture sub-sector is relatively new and makes a little total contribution to the national economy (Moroda, 2022). According to 2018/19 CSA data, Ethiopia produces an average of 6,259,428 tons of horticultural crops annually. However, due to limitations in harvesting and processing technologies, postharvest losses range 1,251,886 to 3,129,714 tons each year. This results in a total loss of 20-50% of the country's annual horticultural production (CSA, 2019).

Postharvest loss occurs at every stage of the market chain, from harvest to all postharvest processes before consumption. They are unexpected consequence of the technical, institutional and legal frameworks that produce supply chain systems and production systems operate within (Yahia *et al.*, 2019). Ethiopia, between 2009 and 2019 lost nearly 10% of its annual budget to postharvest losses accounting to the \$1.2 billion annually, primarily from major food and cash crops (Tadesse, 2022). Fruit and vegetable postharvest losses in Ethiopia are the highest (33.38%) followed by cereal (23.36%), pulse and oilseed (23.25%) (Sisay, 2022). Vegetables, specifically tomato postharvest losses on average, range from 7.31 - 45.32% (Mohammed and Afework 2018; Eskindir *et al.*, 2021; Fentahun *et al.*, 2019).

Postharvest loss of tomato is one of the major challenges faced by tomato producers and along the market chain. Hence, assessment of tomato postharvest loss along market chain is important to find out the possible points of action in order to reduce postharvest losses that may benefit producers and other actors in the chain. Therefore, this study examined how tomato postharvest loss affected market chain actors' performance and identified determinants of postharvest loss of tomato among smallholder farmers in Adea district, Ethiopia.

## 1.2. Statement of the Problem

Postharvest losses have a direct effect on farmers' livelihoods whose survival depends on the income they receive from their product. Farmers' ability to invest in better agricultural practices, technology and inputs is limited by these losses which also lower the amount of produce that reach the market. Furthermore, postharvest losses increase food insecurity by reducing the amount of product available for export and local consumption (Morris *et al.*, 2019). Fruits and vegetables are often harvested with high water content, typically over 90% making them highly perishable and in turn resulting losses (Njume *et al.*, 2020). It is estimated that postharvest losses of fruits and vegetables ranges from 5-20% for developed countries, while in developing nations, losses can be as high as 20-50% (Kitinoja and Kader, 2015).

Postharvest losses in developing countries are often attributed to inadequate cold storage, poor packaging for storage and transport, weak infrastructure limited processing facilities and improper handling. However, in Ethiopia, significant postharvest losses of horticultural crops occur during harvesting, marketing, transportation, and storage. Harvesting is the most commonly cited stage for losses followed by marketing (Henock and Biresaw, 2014; Mohammed and Afework, 2018). Postharvest loss on vegetables could reach up-to 40% after harvest (Tilahun *et al.*, 2011; Tilahun *et al.* 2012; Bezabih *et al.*, 2017). For instance, 11.82% in Arsi zone, 18% in Debremarkos, and 42% in SNNP due to poor handling, poor packaging materials and storage, lack of transportation, disease and market distance were recorded (Bezabih *et al.*, 2015; Yonas *et al.*, 2020; Berhanu, 2018; Zelalem *et al.*, 2021). This indicates that Ethiopia faces larger postharvest loss.

Although tomatoes are highly nutritious and economically valuable, their shelf life is limited due to factors like inadequate technology and a lack of awareness among producers and market actors, resulting in poor handling and storage practices (Gezai *et al.*, 2020). While some studies have examined postharvest loss of tomato along the market chains taking into consideration the postharvest handling practices, research specifically estimating these losses in Adea district remains absent. This will in turn help to identify factors responsible for the losses (Bezabih *et al.*, 2017; Eskinder *et al.*, 2021; 2021; Gezai *et al.*, 2020; Mohammed and Afework, 2018).

Smallholder farmers often face limited access to proper storage facilities, transportation and market information, which significantly contributes to higher postharvest losses (Fantahun *et al.*, 2019; Alidu *et al.*, 2016). A number of factors such as socioeconomic, demographic, institutional and technical influence tomato postharvest losses (Sibomana *et al.*, 2016; Bezabih *et al.*, 2017; Deribe and Tewodros, 2024). Determinants of postharvest losses vary depending on the type of crop, growing area, climate, pre-harvest practices, postharvest handling and other factors. In the case of tomato, lack of awareness, carelessness on the loss and its impact, physical/mechanical damage, disease/pest infection, information, credit access and others can either positively or negatively affect tomatoes in Western Oromia, Sidama Zone and Bora and Dugda districts respectively (Kifle *et al.*, 2022; Zelalem *et al.*, 2021; Bezabih *et al.*, 2017). However, the level and determinants of postharvest losses vary from place to place, socioeconomic and institutional setup (Aidoo *et al.*, 2014; Gezai *et al.*, 2020; Bezabih *et al.*, 2017; Goka *et al.*, 2021; Sisay 2022).

As such this study examined postharvest loss of tomatoes along the market chain and identified determinants of postharvest loss of tomato among smallholder farmers in Adea district, East Shewa Zone, Oromia Regional State, Ethiopia.

### **1.3. Research Questions**

The research attempts to answer these questions.

1. Who are the actors in the tomato market chain and their interactions in the study area?
2. What are the estimates of tomato postharvest loss along market chain actors in the study area?
3. What do the performance of tomato market looks like?
4. What are the determinants of postharvest losses among smallholder farmers?

### **1.4. Objective of the Study**

#### **1.4.1. General objective**

- The general objective of this study is to assess tomato market chain and postharvest loss in Adea district of East Shewa Zone.

#### **1.4.2. Specific objective**

- To identify the market chain actors of tomato and their roles in the study area.
- To analyze the performance of tomato market chain actors.
- To identify the determinants of postharvest loss of tomato among smallholder farmers in the study area.

#### **1.5. Significance of the Study**

The study's importance lies in determining estimates of postharvest losses of the actors in the tomato market chain as well as the factors that lead to postharvest losses among smallholder farmers. The result of findings will be used to create interventions aimed at reducing postharvest losses while identified factors contributing to these losses that will guide the development of effective postharvest loss reduction strategies. This in turn offers useful data that might be applied to raise tomato market's effectiveness. Apart from the above mentioned reasons to conduct this study, gaining a better understanding of the factors contributing to postharvest losses is vital for identifying which element hinders or facilitate these losses. By focusing on the specific needs and challenges of these farmers, a more sustainable and efficient tomato market chain can be developed. Targeted policy and interventions at this level can have a profound impact on the entire tomato sector, as smallholder farmers play a crucial role in the overall production and supply of tomatoes.

#### **1.6. Scope and Limitation of the Study**

The study was confined to two *kebeles* of Adea district, Godino and K'at'ila, which are well-known for tomato production. Data were collected from these selected areas with the intention to avoid generalizations about the entire region. While farmers in the study area cultivate a variety of crops, this research focused exclusively on tomato crop using data from a single year. To achieve this objective, cross-sectional data were collected from 171 sample households to ensure adequate representation. Cross-sectional data capture information at a single point in time, which may not fully account for seasonal variations, year to year changes or long term trends in tomato production and postharvest losses. This constraint may affect the

generalizability and comprehensive understanding of the factors influencing tomato losses in the study area.

## **1.7. Organization of the Thesis**

The thesis is structured into five chapters. Chapter one covers the background, problem statement, research question, objectives, significance of the study, scope and limitations, and thesis organization. Chapter two provides a review of relevant theoretical and empirical evidences. Chapter three delves into the research methodology; including the study area description, data types and sources, data collection methods, sampling techniques, and data analysis methods. Chapter four presents the results and discussions on the socio-economic and demographic characteristics of famers and traders in the study area, a comparison of gross margin with and without loss, and the factors influencing postharvest loss of tomato among smallholder farmers. Chapter five summarizes the main findings, draws conclusions and offers recommendations.

## 2. LITERATURE REVIEW

### 2.1. Concepts and Definitions

**Marketing:** marketing is a social and managerial process through which people and groups fulfill their needs and desires by producing and trading goods and values with others (Kotler *et al.*, 1999).

**Market chain:** A market chain refers to the interconnected network of actors and transactions involved in transferring agricultural products from the farm to end consumer. Within the chain, farmers need to understand market operations and strategically align their enterprise to enhance their performance (Lundy *et al.*, 2007). It consists of three key components: production, postharvest processing and marketing, each with its respective links and functions (Spilsbury *et al.*, 2004).

**Marketing channels:** A marketing channel consists of interconnected organizations that work together to deliver a product or commodity for use or consumption (Stern *et al.*, 1996). It facilitates the transfer of goods from producers to consumers by bridging gaps in time, location and ownership (Kotler and Keller, 2012). A marketing channel involves multiple entities working together, rather than a single firm whether producer, wholesaler or retailer acting independently (Lee and Lee, 2009). Channel members play essential roles with some functions, such as storage, movement and communication flowing from producers to consumers (forward flow). Others, like ordering and payment move in the opposite directions (backward flow), while activities such as information exchange, negotiation and financing, and risk management occurs in both directions (Lee and Lee, 2009).

**Postharvest losses:** Different definitions of Postharvest losses have been carried out by various researchers.

Postharvest losses can be defined as losses that appear while harvesting or after harvest that can occur at any point along the value chain up until the crop is consumed (Ambler *et al.*, 2018). They include both damage and complete loss in which damage relates to reduction of quality of crops but are still useful in some part while complete loss, as its name indicates is

complete loss. The quality and quantity loss of food from the point of harvest up to the point of consumption can also be another definition of postharvest loss (Sawicka, 2019). Researchers also defined postharvest loss in different terms and scopes. Postharvest loss and waste (PLW) is one scope and it refers to ineffective use of horticultural financial investments especially no-renewable natural resources (Shipman *et al.*, 2021).

Food loss and waste is another term used to define postharvest loss. According to FAO (2018: 4), food loss consists of all the food produced for human consumption that is not eaten by humans, while food waste is considered to be part of food loss and is understood as food intended for human consumption being discarded or left to spoil as a result of decisions taken by actors along the food supply chain.

According to Kiaya (2014), Food losses are mostly caused by inadequate infrastructure and logistics, lack of knowledge, skills, and management ability among market chain participants, as well as lack of market while food waste occurs at all points in the food supply chain, including retail and final consumption and is influenced by consumer and retail behavior. The Majority of food loss and food waste occurs at distribution and consumption phases while in low income countries they take place at production and postharvest stages. Lu *et al.* (2022) defined food loss as the loss of edible components besides the non-edible once and also seeds, during agricultural production, postharvest handling, storage processing and distribution of agricultural goods due to equipment, human and technical causes

## **2.2. Pre and Postharvest Activities of Tomato**

**Irrigation:** Proper irrigation planning is essential for optimal growth and nutrient retention, while effective water management is key to ensuring high-quality crops and maximum yields (Adewoyin, 2023). Deficit irrigation was found to reduce water accumulation and fresh yield in tomatoes while increasing total soluble solids in the fruit (Mitchell *et al.*, 1991). In general, crops with high moisture content or low dry matter tend to have poor storage quality (Adewoyini, 2023).

**Pruning:** fruit pruning helps control the number of fruits per cluster, reducing competition and promoting increased weight (Hanna, 2009). The impact of pruning on fruit quality traits varies

based on factors such as the developmental stage of the sink, fruit to leaf ratio, truss position and the plant's genetic composition (Mbonihankuye *et al.*, 2013; Lhamo *et al.*, 2022). Proper pruning improves fruit texture by optimizing light distribution across all fruits on the tree. Conversely, improper pruning can cause fruit shading, leading to smaller, under-ripe fruits with a hard and grainy texture (Adewoyini, 2023).

**Fertilizer application:** fertilization is a key agricultural practice that influences tomato quality both before and after harvest (Melkamu *et al.*, 2008). The choice of fertilizer type and application rate during production depends on the crop's intended purpose desired quality traits (Arah *et al.*, 2015). Calcium Nitrate should be used in integrated plant production due to its environmental benefits and its ability to enhance both productivity and crop quality (Manmohan and Verma, 2022).

**Pest and disease management:** tomato crop face threats from pests (*Tuta absoluta*) and diseases like *Fusarium*, early blight, and late blight. A sustainable solution for these involve an integrated approach combining cultural practices, fungicide application and the use of genetically resistant cultivars (Sora and Sakata, 2022).

**Cleaning and washing:** soil-borne microorganisms that cause decay can lead to fruit rot, making it essential to clean fruits before marketing (Esuguerra and Rolle, 2018). To prevent chilling and the subsequent absorption of water and microbes into the tomato tissues, the washing water should be warmer than the tomato pulp (Smith *et al.*, 2007). Tomatoes are vulnerable to postharvest fungal and bacterial infections that can enter through minor cracks or scratches. To minimize the risk, infected fruits should be removed immediately while healthy once should be properly washed and disinfected (Drvosha, 2024).

**Sorting/ grading:** sorting involves removing rotten, damaged or diseased fruits to separate them from healthy once as damaged fruits release ethylene, which can impact nearby produce (Saltveit, 1991). Grading on the other hand, categorizes fruits and vegetables based on color, size, maturity stage, or ripeness. Both processes are essential for preserving the postharvest shelf life and quality of tomatoes (Arah *et al.*, 2016). Sorting is carried out on a simple table with sorters positioned on both sides, allowing tomatoes to be packed directly into containers.

This method helps prevent contact with soil, reducing the risk of contamination (Esguerra and Rolle, 2018).

**Packaging:** tomatoes are packed fresh and clean, free from plant protection residues, moisture, rot or damage (Drvosha, 2024). Tomatoes are packaged differently depending on their maturity level, fruit type, ripeness stage, market requirements and customer preferences (Yahia and Brecht, 2012). Plastic crates are highly recommended for tomatoes as they offer excellent protection against compression damage. Their smooth interior prevents bruising, are easy to clean and can be stacked, reused and returned (Esguerra and Rolle, 2018). In many developing countries, especially in Africa, wooden crates and woven palm baskets are commonly used for packaging tomatoes. However, a major drawback of wooden crates is their height, which exerts excessive compressive force on the tomatoes at the bottom (Kelly *et al.*, 2010). These excessive compressive forces lead to internal damage, ultimately reducing the postharvest quality of the tomatoes (Arah *et al.*, 2016).

**Storage:** due to its high moisture content, tomatoes are difficult to store at ambient conditions for more than a week. For long term storage, they should be kept at 10-15 °C and a relative humidity of 85-95% to minimize losses (Drvosha, 2024). A variety of storage structures are used globally to effectively store horticultural produce. These structures must maintain cool conditions (either refrigerated or well-ventilated and shaded), and the produce stored should be of high initial quality (Kiaya, 2014).

**Transportation:** in many developing countries, tomato production sites are often located far from markets and lack proper road access. The poor road network and absence of suitable transportation, such as refrigerated vans, pose significant challenges for both producers and distributors when transporting harvested tomatoes (Adepoju, 2014). Transportation of tomato typically involves several stages, beginning with their transfer from farm to a collection center or packing facility, followed by delivery to the wholesale market and ultimately reaching the retail market (Esguerra and Rolle, 2018).

### 2.3. Pre and Postharvest Activities Effect on Tomato Loss

Activities that hold before the harvesting of a product i.e. pre-harvest and postharvest have effects on the produce. Some pre-harvest activities in tomato value chain are:

**Climatic conditions:** Tomato is one of the most important vegetable grown outdoors but is impacted by climate change (Litskas *et al.*, 2019). This increases the chance of tomato cultivation to be impacted by global warming (Silva *et al.*, 2017). Climate shocks like drought and heavy rainfall reduces production activity and lowers revenues (Benabderrazik *et al.*, 2022). Although increased incidence of diseases due to climate change occurs, pesticide applications also increased to cope the effect of pests and cold (Bhandari *et al.*, 2021).

**Cultivar type:** a producer must make a crucial choice when selecting a tomato cultivar to provide acceptable yields, desirable fruit attributes and a long shelf life. A poor cultivar choice could result in fewer yields, fruit of lesser quality or crops that are less marketable. Many cultivars have fruits that vary in size, flavor, color, texture and storage capacity (Tamnaw *et al.*, 2021). According to Yebirzaf and Kassaye (2018), varieties that are grown in the field resulted in highest fruit weight loss. The fruit weight loss in tomato cultivar has a detrimental impact on fruit's firmness, overall appearance and shelf life (Yeboah *et al.*, 2014).

**Irrigation:** increment in water content fastens the loss of fruit firmness (Sibomana *et al.*, 2015). Some studies focus on deficit irrigation which is considered to have both positive and negative effects on physicochemical quality of tomato fruits. Deficit irrigation causes increase in firmness, total soluble solids, and titratable acidity of tomato fruits while decreasing pH of tomato fruits with decreasing water applications (Agbemafle *et al.*, 2014).

**Maturity stage:** fruit quality and ripening parameters are greatly impacted by maturity stages (Priyankara *et al.*, 2017). It is a crucial element influencing the postharvest quality of tomatoes for the fresh markets and other processed tomato products (Tilahun, 2013). Maturity stages might include breaker stage, pale red and light red (John *et al.*, 2020), color breaker, 25% maturity and 50% maturity (Priyankara *et al.*, 2017) and breaker, pink and red stages (Shimeles *et al.*, 2019). The breaker stages are the stages which are most suitable for storage.

Postharvest activities that have an effect on tomato loss are the following:

**Temperature:** the quality properties of tomato fruit i.e. soluble solid content, color, firmness, weight loss and chilling injury have different growth temperatures depending on the cultivar types (Affandi *et al.*, 2022). At storage temperatures of 5°C, 13°C and simulated condition, normal ripening occurred at 13°C but the ripening process was interfered at 5°C and simulated condition (Hatami *et al.*, 2012). Another study conducted by Ponce-Valadez *et al.* (2016) showed that compared to tomato fruits stored at 10°C, those stored at 12.5°C maintain a higher level of sensory quality.

**Relative humidity:** Firmness, amount of carotenoids and physiological weight loss of fresh tomatoes are all impacted by postharvest storage temperature and relative humidity (Abiso *et al.*, 2015). Depending on the available storages, harvested fruits retain their nutritional value, appearance, weight and flavor at very high relative humidity levels while slowing the rate of wilting, softening, and juiciness development (Arah *et al.*, 2015). At ambient conditions, the relative humidity ranged between 29 and 68% with the average being 55% and depending on time, differences in humidity was observed at minimum and maximum i.e. 3.11% at 6:00 hr. and 6.99% at 11:30 hr. (Solomon, 2018).

**Handling:** high amount of loss, particularly in developing countries, have been caused by failure to follow suitable postharvest handling procedures and treatment techniques (Arah *et al.*, 2016). Multiple handling frequently enhances a decline in tomato quality and increase fruit injuries by causing an increase in ethylene production and enhanced respiration (Cherono *et al.*, 2018).

**Packaging:** packaging helps to ensure quality, make food products easier to handle, and extend their shelf life while being transported and stored (Mibulo *et al.*, 2020). But the usual usage of synthetic based materials for advanced packaging leads to environmental issues because of their non-biodegradability and safety issues. Thus, the usage of papaya as a basis of designing and tomato package has a significant effect increasing the shelf life of the product. Packaging has a considerable impact on the physiological weight loss, decay rate, color score, overall acceptability and marketability of tomato fruits. Packing with a perforated low density polyethylene bag enhances the shelf life and quality of tomato produce (Ashenafi and Tura, 2018).

**Storage:** temperature, humidity and air composition have a significant effect on the quality of tomatoes. Although controlled atmosphere storage is mostly suggested to increase the shelf life and quality of tomato, its use is quite constrained in many countries due to its expensiveness and complicated technical requirements (Jung *et al.*, 2019). Weight, color and firmness are examples of physical quality traits that were found to be significantly influenced by storage temperature and time. Every quality change was accelerated by storage at room temperature (22°C). However, storage at a lower temperature of 10°C resulted in slower reductions and enhancement of the analyzed parameters due to transport distance, storage time and storage condition (Al-Dairi *et al.*, 2021). Another study concluded that, with storage temperature of 10°C, both tomatoes with and without water stress had their lycopene and color values raised (Khairi *et al.*, 2015).

**Transport:** transportation, as one of the most important operation accounts up to 20% postharvest quality loss in supply chains for fresh tomatoes in Africa and other emerging economies (Cherono and Tilahun, 2018). The amount of vibration produced during transportation is influenced by the length of the transport which is harmful for the produce (Al-Dairi *et al.*, 2021). Before tomatoes reach consumers, there is a higher rate of spoilage due to the longer hour journey from farm to market centers transporting already ripped tomatoes over uneven roads (Fagbemi *et al.*, 2022).

## **2.4. Theoretical Framework**

### **2.4.1. Market chain analysis**

Market chain analysis is a structured approach used to evaluate the connections between different actors and processes involved in moving agricultural products from production to the final consumer (CIAT, 2004; Lundy *et al.*, 2004). It maps the flow of goods and from their origin to their final market, highlighting the roles of key participants such as producers, traders, transporters, processors and consumer. This analysis examines crucial elements, including market dynamics, transaction costs and the specific functions carried out at each stage, along with the relationships and interactions among stakeholders (FAO 2005). Additionally market chain analysis focuses on identifying market constraints and opportunities while assessing demand patterns, whether increasing, stable or declining. By offering insights

into the chains efficiency, this method helps pinpoint areas needing intervention to improve value addition, optimize efficiency and ensure a fair distribution of benefits among all participants (CIAT, 2004; Webber and Labaste, 2010).

#### **2.4.2. Commodity system assessment methodology**

The commodity system analysis methodology (CSAM) is a structured and systematic framework designed to evaluate postharvest losses in perishable crops. This method dissects the entire commodity system into smaller, more manageable segments, facilitating the identification of constraints that contribute to both qualitative and quantitative losses. By collecting data from various sources, including written reports, field observations, interviews and other credible references, CSAM offers a comprehensive approach to analyzing and addressing challenges within a specific supply chain (Kitinoja, 2011; Fidafrigue, 2007).

CSAM's multidisciplinary approach highlights the importance of collaboration among stakeholders and experts from various fields to develop practical and cost-effective solutions (La Gra, 1990). Additionally the methodology provides valuable insights into the roles and incentives of different actors within the value chain, ensuring a thorough understanding of the system. This, in turn, strengthens strategies aimed at minimizing postharvest losses while enhancing food quality and optimizing supply chain efficiency (Kader and Rolle, 2004).

The CSAM framework does not seek to differentiate between the supply chain and value chain or their end goals. Rather, it follows established methodologies to ensure a validated approach that can be applied across various settings. While it examines each component of the system separately to collect vital information for loss reduction strategies, key issues can also be addressed from a value chain perspective (Gezai, 2013).

### **2.5. Fundamental Approaches to Market Chain Study**

There exist three approaches to study market chain. These are functional, commodity and institutional approaches.

### **2.5.1. Functional approach**

One of the main specialized tasks carried out to complete the marketing process is called marketing function (Kohl and Uhl, 1985). However, Ahmed (1995) views this approach as dealing with ‘jobs which should be done.’ Many marketing operations including purchasing, selling, financing, transportation, banking, taking on risk, and gathering market data, can be taken into consideration. It’s hard to figure out which marketing tasks are essential and which once can be skipped since there’s just so many of them (Ravikumar and Prabha, 2019). This approach is relevant as it highlights the key marketing functions such as transportation, risk management all of which can influence postharvest losses.

### **2.5.2. Commodity approach**

Products and services are classified as market exchange objects under the commodity approach (Shaw and Jones, 2005). A person researches the source of supply, the kind and amount of demand, the reason for the need, the mode of transportation, issues related to storage, standardization, packaging, branding, etc. The descriptive approach is the name given to this type of method, and it is said to provide benefits in and on itself (Ravikumar and Prabha, 2019). This approach considers factors such as storage, transportation, packaging which are key elements in understanding where and how postharvest losses occur.

### **2.5.3. Institutional approach**

This approach involves marketing descriptions and analyses of diverse firms and gives each sort of marketing organization’s issues and operations special attention. Producers, wholesalers, agents, retailers and companies that facilitate activities like transportation and warehousing are typically included in the organization (Ravikumar and Prabha, 2019).

The different types of middlemen involved in the marketing process, as well as their behaviors, are outlined by the institutional approach (Shaw and Jones, 2005). This approach is highly relevant as it outlines the roles of different market actors in the chain. Since one of the objectives of this study is identifying market chain actors and their role, this approach provides a useful perspective on actor interactions and responsibilities.

## 2.6. Analytical Framework

### 2.6.1. Techniques in measuring performance of a market

Market performance refers to the efficiency and effectiveness of an industry in terms of its ability to produce and distribute goods and services. It is often measured using indicators such as profitability, growth, productive or allocative efficiency (Tesfaye and Abdurezak, 2018). To evaluate profitability of tomato market chain actors, so far researchers have used profitability ratio, gross profit margin, marketing margin and gross margin. A profitability ratio is a ratio used to assess a company's capacity to turn a profit over a certain time frame and to give a general idea of how well management is doing its duties (Miransyah *et al.*, 2021).

Profitability can also be calculated after the conformity of cost and return analysis i.e. total revenue, total variable cost and gross margin (Olugbire *et al.*, 2020). Using this ratio to examine the effects of tomato postharvest loss on profitability of each actor in the supply chain will provide insight into the financial impact of postharvest loss and also allow for comparison before and after implementing measures to reduce postharvest losses. However, it might not capture the full extent of the impact of postharvest losses on market supply chain actors, may not reflect future performance, and it is not suitable for all aspects of postharvest losses i.e. aspects such as quality deterioration may not be fully captured and may require additional metrics for a comprehensive assessment.

The ratio of gross profit to revenue is known as gross profit margin. The starting point index for analyzing an enterprise's profitability is its gross profit margin (Shi *et al.*, 2021). It is obtained by dividing the gross profit by sale. While the gross profit on the other hand is calculated by deducting total variable cost from total revenue (Adepoju, 2014). The only difference between gross profit margin and gross margin is that gross profit is expressed in percentage. The advantage of using both when examining profitability is that they are simple and widely used metrics and easy to calculate and understand making them accessible for market chain actors. Their limited scope of not capturing the full extent of impact, not suitable for all aspects of postharvest loss and chain actors manipulating their cost of goods sold or

revenue figures making it difficult to accurately assess the effect of postharvest loss on their profitability can be taken as limitations of using both gross profit margin and gross margin.

The percentage of the final selling price that a certain agent in the marketing receives is measured by their marketing margin (Mendoza, 1995). Surveys for margin determination must be carried out concurrently with channel surveys. The queries, “from whom did you buy?” and “to whom did you sell?” might be used to identify the channel. However, in order to learn about the margins one must respond to inquiries, “what price did you pay?” and “what was the selling price?” throughout the entire chain. Using marketing margin is advantageous in that it focuses on the entire supply chain and it reflects market dynamics providing insights on how postharvest losses affect market price and overall profitability. The complexity of calculating marketing margin, limited specific market dynamics and price structures, not accounting for non-financial factors and not reflecting future performance are among the limitations of marketing margin.

### **2.6.2. Measures of determinants of tomato postharvest loss among smallholder farmers**

So far researchers have employed different models to identify the determinants of postharvest losses among smallholder farmers. The most frequently used models are multiple linear regressions, ordered probit model and Tobit model.

Multiple linear regressions are a statistical method that forecasts the outcome of a dependent variable using two or more independent variables. Multiple linear regression attempts to model the linear relationship between the independent (explanatory) and response (dependent) variables. Since it takes into account several explanatory variables, multiple linear regressions are essentially an extension of ordinary least squares (OLS) regression. According to pertinent econometric criteria, such as the signs of the coefficients in line with a priori expectations, the number of significant variables, F-statistics and the value of coefficients of multiple determinations, out of the four functional forms i.e. double log, exponential, semi-log and linear models, the double-log function give the best fit (Falola *et al.*, 2023).

Despite their easily interpretable nature, the major limitation with multiple linear regressions in the case of postharvest losses is that it assumes that there is no linear relationship between

explanatory variables (Gujarati, 2004), where this assumption is not applicable when identifying determinants of postharvest losses since almost all the factors are correlated or dependent on each other. The model also assumes that the parameters are linear and not the variables. In addition, the model is not applicable if the dependent variable is censored.

The ordered probit model is the other model used to study determinants of postharvest losses among smallholder farmers. The ordered response model is used when there is an ordered or logical ordering of the alternatives, indicating that the outcomes in this situation will depend on how the alternatives are numbered (Garikai, 2014). The model can be used to combine several variables that affect the various postharvest loss categories for a particular crop. The model being specifically designed for ordered outcome variables is the main limitation. In addition, interpreting coefficients directly as marginal effects on the expected value of the dependent variable is challenging.

The last approach to identify factors of postharvest loss among smallholder farmers is Tobit (censored regression) model proposed by Tobin (1958). It is a hybrid of continuous and discrete models which can determine the intensity of losses at it relates to each independent variable (Mbuk *et al.*, 2011). In the case of postharvest losses, the dependent variable is frequently constrained at zero (i.e. losses cannot be negative), and there may be a significant number of observations with zero losses. These censored observations may be included in the Tobit model, which also offers more precise estimates of the factors that influence postharvest losses. The Tobit model estimates the parameters for both the censored and uncensored parts of the data, providing comprehensive analysis. The model provides consistent estimates and can handle heteroscedasticity.

The model provides limited interpretation of coefficients compared to multiple linear regressions. Additionally, if the errors in the model are not normally distributed and the relationship between the dependent and independent variable is nonlinear, the model is not applicable. In general, it can be concluded that there are no real models before beginning to build one. Models can only approximate. The next step is to determine which model, in light of the evidence we will gather, would most closely resemble reality. This suggests that we may test each model and compare them to determine which is best (Gemechu, 2019).

## 2.7. Empirical Review

### 2.7.1. Tomato Postharvest Loss along Chain Actors

According to Mebratie *et al.* (2015), the estimated losses of banana in central Ethiopia was 26.5%, with 56%, occurring at the retail stage, followed by 27% at the wholesale level and 17% at the farm level. Mechanical damage was the primary cause of losses at the farm and wholesale stages, while rotting was the main factor at the retail level. Poor postharvest handling practices from farm to retail were the major contributors to these losses.

In west *shewa* zone, the average harvesting loss at producer level was 3.14% of total production, primarily caused by insect damage, rotting, cutting losses and potatoes left in the soil during harvesting. At retail level, the average loss across all area was 7.59% of the total potatoes purchased, mainly because potatoes already affected at producer level deteriorate quickly when exposed to high temperatures and unsafe storage conditions. Wholesale level losses were recorded at 16.71% largely due to the lack of proper cold storage. Wholesalers typically store potatoes on the warehouse floor for one week to a month, leading to significant postharvest loss (Misrak *et al.*, 2014).

In Akaki, farm level the average postharvest loss of cabbage is 4%, mainly due to poor storage conditions, harvesting damage and diseases. At the wholesale level, losses were recorded at 29.5% which is the highest and is attributed to poor storage conditions, transportation damage, inadequate packaging, low quality purchased cabbage, and diseases. At the retail level, 17.6% of losses occurred due to poor storage conditions, transportation damage, inadequate packaging, unsold vegetables, low quality purchased cabbage and diseases (Dimtsu, 2014).

Postharvest losses among tomato producers indicate that the average loss at the production level is approximately 20.45% in East Shewa Zone. The highest loss occurs from tomatoes left unharvested in the field, which may result from market constraints, oversupply or quality issues. In contrast, lowest loss was attributed to improper loading and unloading, highlighting handling inefficiencies at different points in the supply chains. Additionally, wholesalers experience an 8.63% loss from field loading and unloading at the final destination, factoring in transportation and handling issues. At the retail level, postharvest losses are comparatively

lower, with 1.53% loss due to transport and 1.40% loss due to mishandling (Gezai *et al.*, 2020).

According to Zelalem *et al.* (2021), in selected districts of Sidama Zone, producers have incurred a loss of 24% with the highest loss occurring due to diseases and pests. On the other hand, the lowest loss occurred due to lack of sorting, reflecting minimal losses attributed to sorting inefficiencies. At the retail level, 3% loss was recorded which is relatively lower compared to other stages. This lower loss may be attributed to the absence of sorting and additional handling activities that typically causes damage at earlier stage. In contrast, wholesalers experienced 9% losses which include losses incurred from field loading, transportation handling and unloading at the final destination.

In Northwestern Ethiopia, postharvest losses of tomatoes were quantified at 3.81% and 10.75% for wholesalers and retailers, respectively. These losses were primarily attributed to poor handling and packaging, inadequate storage infrastructure, and unhygienic conditions in local open air markets, which accelerate spoilage and reduce overall tomato quality (Eskinder *et al.*, 2021).

### **2.7.2. Determinants of postharvest loss**

Several academics identified certain aspects affect fruit and vegetable after harvest when determining the postharvest loss factors. The categories for these are mechanical, chemical, biological, physiological, physical and environmental aspects (Kitinoja and AlHassan, 2010; Atanda *et al.*, 2011; Kader, 2004; World Bank, FAO and NRI, 2011; FAO, 2011; Muluaem *et al.*, 2015). Socioeconomic variables such as age, education level, household size, farm size and experience were anticipated to have both a positive and negative influence on tomato losses. Other factors such as distance from farm to market, lack of storage facilities, inappropriate packaging and increment in the number of baskets harvested also influence tomato losses (Ayandiji *et al.*, 2011).

Abera *et al.* (2022) assessed Avocado postharvest loss at producers level in Wolaita and Kembata Tembaro zones using multiple linear regression. Determinants such as sex, training on avocado management system, income generated from avocado, education level, off farm

income level and number of days of extension contact negatively affected postharvest loss. While harvesting method, availability of storage and distance to nearest road were found to have positive effect on postharvest losses of avocado.

According to Desale *et al.* (2019) findings, using multiple linear regressions, the factors that were significantly and favorably correlated with sesame grain loss in Kefata Humera districts included farm size, total amount of sesame grain produced, weather conditions, the distance that piles were transported, stacking days, the distance of the sesame farm and the mode of grain transportation. However, sesame postharvest loss from small-scale growers was strongly and negatively affected by educational levels and extension contacts.

Zenebe *et al.* (2015) conducted a study on assessment of banana postharvest handling practices and losses in Ethiopia using multiple linear analysis. The study identified determinants such as household experience, area of banana land and storage; under natural open shade, in open covered with banana leaves and under ventilated shade house had negative effect. Other factors such as market distance, number of days of storage and storage on open sun without cover had positive effect of postharvest losses of banana at farm level.

Muluken *et al.* (2017) conducted a study on determinants of tomato postharvest loss of fruits in Northwestern Ethiopia. The study used multiple linear regressions and identified factors that affect producer storages which were chemical treatments before storage and educational levels of producers. The study found that the loss at producer's storage facility would typically decrease by 26.9% for every additional year of experience. Comparatively, applying pesticides to the fruit before storage decreased fruit loss by 27.5% compared to storage without chemical treatment.

A study conducted in Dire Dawa on postharvest loss and quality deterioration of horticultural crops used descriptive statistics that contributed to highest postharvest loss for tomato. Climate and weather conditions, harvesting and handling techniques, packaging, storage and transportation, market situation, disease and pests were pinpointed as the major factors (Mohammed and Afework, 2018).

Studies on identifying determinants of horticultural crops like tomato postharvest loss among smallholder farmers in Ethiopia particularly in Oromia have not been conducted in the study area. Due to the inadequacy of study this paper covered the identification of factors affecting tomato postharvest losses among smallholder farmers in Adea district.

## **2.8. Conceptual Framework**

Postharvest losses of tomato can be influenced by a variety of demographic, technical, institutional and socio-economic factors. Demographic factors such as age, sex, family size, and farm size play a role in determining the ability of farmers to manage and reduce losses. Technical factors as insect pest infestation/rodents and storage problems contribute directly to the degradation of harvested tomato. Access to institutional support such as credit, extension services, training and cooperative membership can empower farmers to mitigate losses. Lastly, socio-economic elements like education level, livestock ownership and distance from main road influence farmer's capacity to adopt postharvest loss reduction techniques. Postharvest losses affect performance of tomato market chain actors. By addressing these losses, the actors can protect their margin and ensure better economic outcome for all involved.

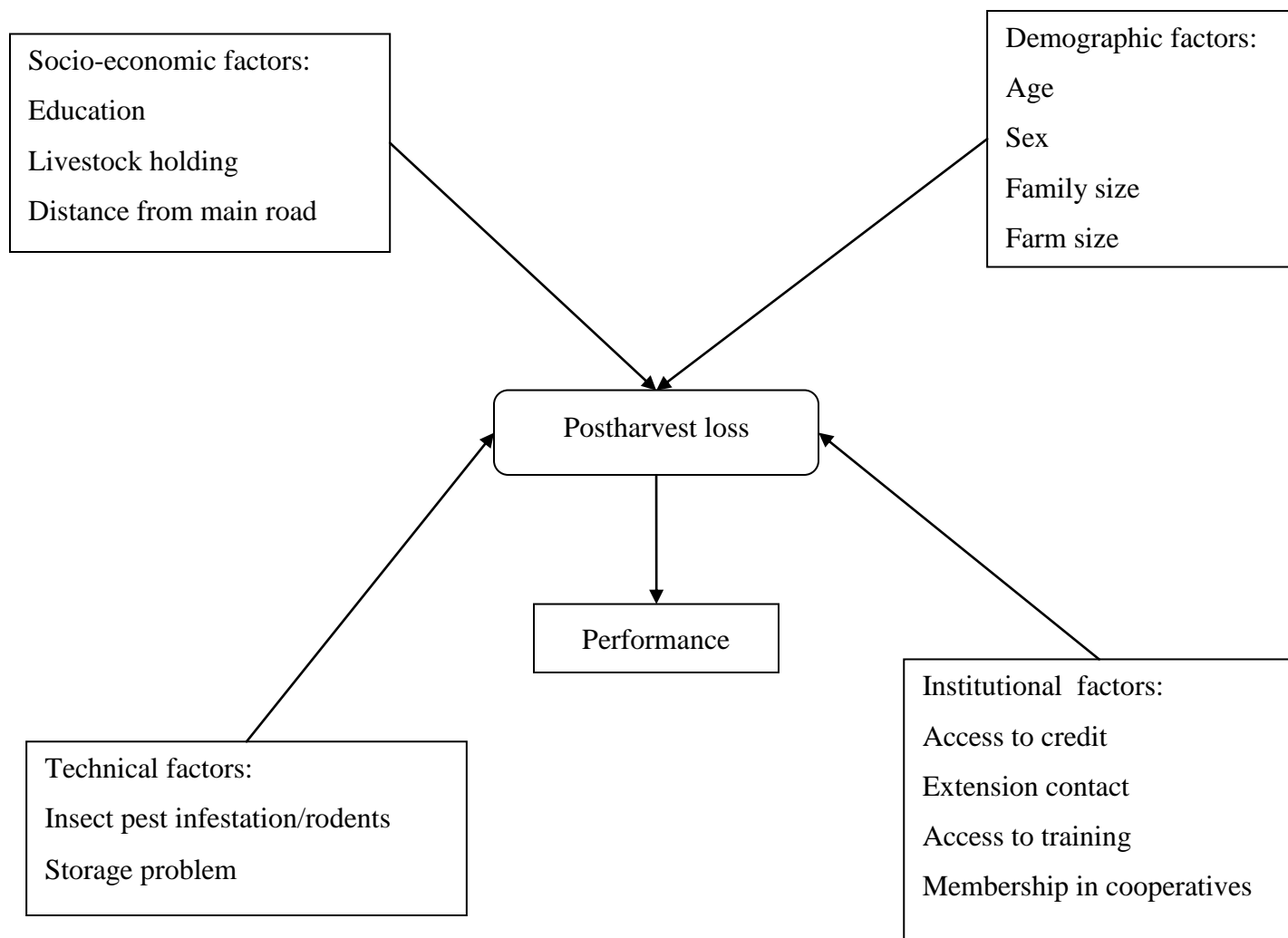


Figure 1. Conceptual framework developed by researchers

Source: Empirical reviews with modification.

### 3. METHODOLOGY

#### 4.1. Description of the Study Area

The study was conducted in Adea district, located in the eastern part of Oromia Regional State specifically in two *kebeles*, Godino and K'at'ila, which are situated approximately 47km from Addis Ababa, the capital city of Ethiopia. It is geographically located 8°28'45''– 8°57'45'' N latitude and 38°37'40''– 39°21'10'' E longitude with an altitude ranging from 1500 to 2400 meters above sea level. It is surrounded by Dugda Bora on the south, the West Shewa Zone on the West, Akaki on the Northwest, Gimbichu on the North and Lome on the East. Lakes namely Bishoftu Lake, Hora Lake, Lake Cheleklaka, Bishoftu Guda Lake and Kuriftu Lake are the main attractions in the region.

The district covers an area of 96,680.33 ha and out of this, 79,917.32 ha of land is under cultivation. The district is divided into three agro-ecology zones: Dega 3%, Woinadega 94% and Kola 3% respectively. According to the National Meteorological Services Agency, the maximum annual temperature of the district were about 28°C from February to May and 24°C from September to November and the mean temperatures were 23°C or lower between June and August. It gets a maximum rainfall amount of 1716 mm and a minimum of 1220 mm annually. *Teff* is a dominant cereal crop in the area which occupies about 45% of cultivated land. Other major crops produced include lentil, horse bean and horticultural crops mainly vegetables. Production of livestock is essential to the system of production. Common practices include the production of cattle, sheep, goats, and cattle, as well as a market oriented method of production that includes dairy and fattening. However, crop production is the primary activity of the farmers. According to data released in 2007, the estimated total population of Adea was 130,321, with 67,869 men and 62,452 women, respectively (CSA, 2007).

In terms of agro-ecology, varied agricultural production is most appropriate for the district. Irrigated agriculture is practiced along several rivers and lakes. The region has two agricultural seasons. Mid June through September is the primary rainy season (*Meher*), while February and March are the dry seasons intercepted by short rainy seasons (*Belg*). The rainy season is crucial for crop production, with *Meher* rain making up approximately 74% of the yearly precipitation.

The district's livelihood predominantly relies on agriculture, with key crops including *teff*, followed by wheat, chickpea and other crops (AWOARD, 2005 as cited by Alemayehu, 2008). Vegetable crops such as onion, tomato, kale, cabbage etc. are also grown. Irrigated horticulture has recently emerged as a growing sector in areas identified for small-scale irrigation development. Livestock farming, managed by smallholders, comprises dairy production, cattle and oxen fattening, poultry farming and fattening of small ruminants (Nigatu *et al.*, 2012). According to Adea district administration office, the area coverage of tomato in 2021 was recorded 300 hectare.

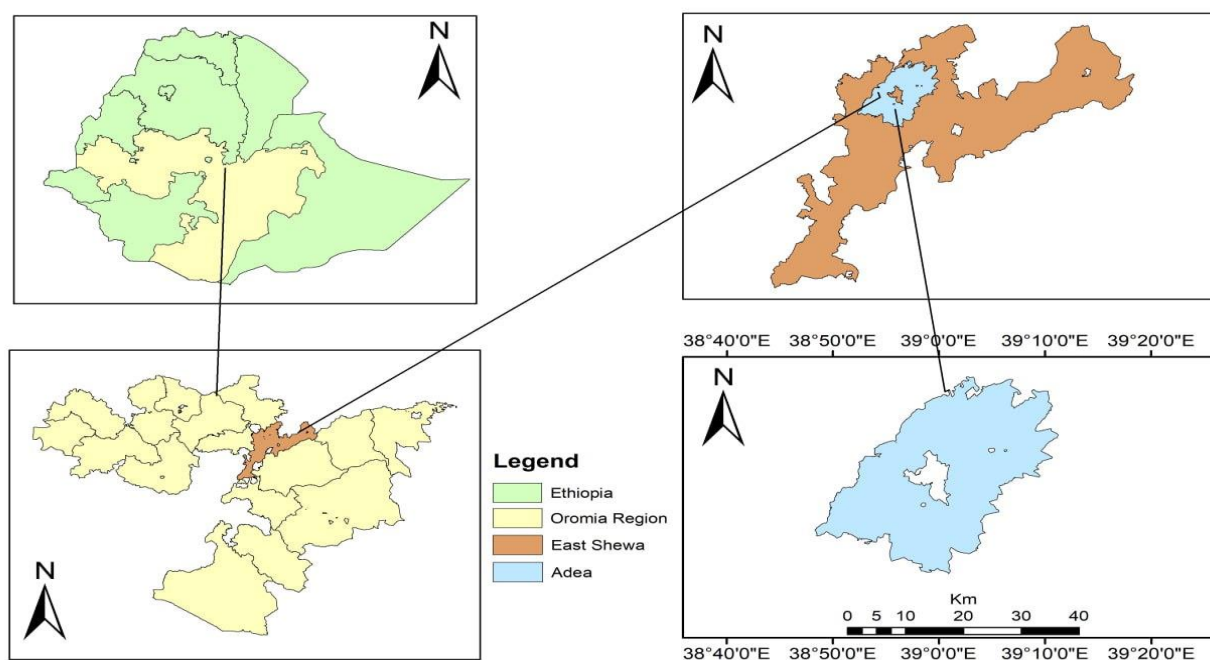


Figure 2. Map of the study Area

Source: Arc Map

#### 4.2. Data Sources and Types and Method of Data Collection

Primary and secondary data was used where primary data's were collected from each actor involved in the chain. The methods that were used to collect the primary data's were questionnaire and Observations. The data's collected through questionnaire included both open and close ended questions. The questions covered demographic characteristics i.e. age, sex, level of education, family size, the chain structure of tomato in the study area; productivity level i.e. how much yield they get monthly/annually; the loss they incur and other

related questions needed to be addressed in the study. Secondary data were collected from both published and unpublished sources.

### 4.3. Sampling Procedure and Sample Size Determination

In this study, Adea district was purposively selected as a study area due to its significant potential for tomato production. A two stage random sampling technique was used to collect data from farmers. In the first stage, 2 *kebeles* were randomly selected from the district's 15 tomato producing *kebeles*. In the second stage, 171 household heads were randomly chosen from a total of 15,310 tomato producers in the district. The number of sampled farmers from each *kebele* was determined proportionally to the total number of households in those *kebeles*. The sample size of 171 was calculated with a 0.076 error, balancing precision with with practical constraints. Similar error margins were employed in comparable studies (Krejcie and Morgan, 1970; Lwanga and Lemeshow, 1999). The total sample size was calculated using the formula proposed by Yemane (1967).

$$n = \frac{N}{1+N(e)^2} = \frac{15,310}{1+15,310(0.076)^2} = \frac{15,310}{1+88.43} \approx 171 \quad 1$$

Where:

n –is the sample size

N –is the population size (total number of households in the district

e –is the desired level of precision

Table 1. Sample size distribution of tomato producers

<i>Kebeles</i>	Tomato producing households	Villages	Sample size
Godino	1,377	Goha Warko	49
		Gifti	45
K'at'ila	1,131	Katila	26
		Danbalo	25
		Boroa	26
<b>Total</b>	<b>2,508</b>		<b>171</b>

Source: Own computation based on regional data, 2018

Regarding other market chain actors sample size, 5 wholesalers, 14 retailers, 5 collectors and 8 consumers were selected using snowball techniques.

#### **4.4. Method of Data Analysis**

##### **4.4.1. Descriptive statistics**

Data was analyzed using descriptive statistics such as mean, frequency, standard deviation and percentages to describe socioeconomic, demographic and institutional characteristics of sample actors involved in tomato market chain.

Calculating gross margin was used in this context to assess performance. Gross margin (GM) represents the difference between total revenue and total variable costs, providing insight into the profitability of each unit sold.

$$GM = \text{Total Revenue} - \text{Total Variable Cost}$$

2

Total revenue refers to the value of output (amount realized for the sale of tomatoes) and is obtained by multiplying the quantity of tomatoes by the unit selling price. While the total variable cost refers to cost of all inputs (pre-harvest and harvest labor wage, transportation costs, and other input costs) (Adepoju, 2014).

To assess the performance of the market chain, it is essential to measure the marketing margin by analyzing the marketing costs and margins of participants in the tomato market in a descriptive manner. Market margin analysis involves comparing prices at different market levels over the same period. It quantifies the portion of the final selling price retained by a specific agent within the marketing chain, typically expressed as a percentage of the price paid the end consumer (Mendoza, 1995). A higher marketing margin suggests minimum or n profit for the agents involved. The total gross marketing margin and the producer's margin were determined using the following formulas below:

The formula to calculate total gross marketing margin (TGMM):

$$TGMM = \frac{\text{End buyer price} - \text{Farmer's price}}{\text{End buyer price}} * 100 \quad 3$$

The formula to calculate producer's margin or share in the consumer price GMMp:

$$GMMp = \frac{\text{Price paid by end buyer} - \text{Gross marketing margin}}{\text{Price paid by end buyer}} * 100 \quad 4$$

#### 4.4.2. Econometric analysis

Econometrically, multiple linear regression models are appropriate to analyze determine the factors associated with postharvest loss at producer's level. OLS models are well suited for this analysis because they can handle multiple influencing factors simultaneously, account for confounding variables and quantify the relationships between independent variables and postharvest loss. Additionally, multiple linear regression models offer robust diagnostics, predictive capabilities and is ideal when the dependent variable is continuous, making it a reliable choice for understanding the determinants of postharvest losses. Because of this they are an effective tool for determining the main factors that influence postharvest loss and for developing targeted interventions that lower loss. Tests such as multicollinearity and heteroscedasticity were checked to before fitting important variables into the model for analysis. The model can be specified as (Greene, 2003):

$$y = \beta_0 + \beta_i X_i + \varepsilon \quad 3$$

Where: Y - Amount of tomato postharvest loss (in birr per quintal)

$\beta_0$  – Constant term (intercept)

$\beta_i$  – Coefficient of  $i^{\text{th}}$  explanatory (independent variable)

$X_i$  – Vector of explanatory variables

$\varepsilon$  - Disturbance (error term)

The linear functional form of the multiple regressions used for continuous and categorical explanatory variables in this study is specified as:

$$PHL = \beta_0 + \beta_1 Age + \beta_2 FAMSZ + \beta_3 EDU + \beta_4 FRMSZ + \beta_5 Matompro + \beta_6 EXTCON + \beta_7 DISMKT + \beta_8 SEX + \beta_9 TRNG + \beta_{10} STRG + \beta_{11} INS + \beta_{12} CRDT + \beta_{13} MCOOP \quad 4$$

Heteroscedasticity refers to the variability of the error terms across several levels of independent variables. Addressing heteroscedasticity can be achieved through robust standard errors, or by changing or adding new variables that capture the pattern of heteroscedasticity. This study used Breusch-Pagan test depending on the collected data.

Multicollinearity is a crucial econometric problem in a model referring to high correlation between independent variables in regression models. It is important to identify and address issues that may affect the accuracy of the coefficient estimates, to identify which variables causing issues and improve efficiency. The Variance Inflation Factor (VIF) is used in this study to check for multicollinearity ensuring robustness of the results obtained. This helps identify inefficiencies in the estimation process and improve the overall accuracy of coefficient estimates.

## 4.5. Definitions of Variables

### 4.5.1. Dependent variables

**Tomato postharvest loss among smallholder farmers:** it is a measure of the total postharvest loss from total tomato production among smallholder farmers.

#### 4.5.2. Independent variables

**Sex of the household head (SEX):** this is a dummy variable that was measured as 1 if household head was male and 0 otherwise. Examining this variable contributes to understanding the differences between male and female-headed household's postharvest activities and access to agricultural support services. According to Gezai *et al.* (2020) finding, men were found to be responsible for farm work while women have the responsibility in reproductive roles, marketing smaller quantities of farm products and purchase food and non-food items for consumption making them less susceptible to losses. In this study sex of the household head is expected to have negative effect on tomato postharvest loss.

**Age of the household head (AGE):** this is a continuous variable measured in years. Age indicates their level of agricultural expertise and potential for making decisions. It includes the experience and expertise gathered over many years of agricultural practices, which influence postharvest techniques and yield. Geazi *et al.* (2020) found that as the age of producers increase, the loss recorded will be relatively higher showing a negative relationship between age of the household head and significance loss of tomato. The same result was obtained by Falola *et al.* (2023) who concluded that compared to their older counterparts, young farmers are more likely to possess the necessary physical strength to do postharvest management, lowering postharvest loss. Age of the household head is expected to have indifferent effect on tomato postharvest loss.

**Education of the household head (EDU):** it is a continuous variable which was measured as the number of schooling years received by the household head. Education enables farmers to be aware of the existence of new technologies and techniques to reduce postharvest losses to increase income of the household heads. In this case, high loss was recorded from literate than the illiterate once due to other options as source of income for the educated farmers (Gezai *et al.*, 2020). In contrast Bezabih *et al.* (2017) concluded that younger framers who have access to education (from high-school to college), they establish good marketing network, use market information and take risk associated with tomato production. In this study education of the household head is expected to have negative effect on tomato postharvest loss.

**Household size (FAMSZ):** it will be measured as a continuous variable by taking the number of family members in the household. After that the members will be categorized according to their sex and age and will then be combined using adult equivalent conversion factors. The majority of the farm's labor supply comes from family labor. Goka *et al.* (2021) reported that family size has negative relationship with the level of postharvest loss i.e. farmers with larger households tend to have lower levels of postharvest losses because they have relatively large amount of family labor to help with tomato harvesting to make the process quicker and more effective. In this study, family size has negative effect on the amount of tomato postharvest loss.

**Distance from main road (DISMKT):** it is the distance from main road where tomatoes are sold. It is a crucial factor affecting postharvest loss since proximity to main road ensures better access to transportation and market facilities, by lowering the risk of spoilage. Kikulwe *et al.* (2018) showed that a 1 km decrement in distance from main road results in a decrease in postharvest loss of banana in Uganda. In this study, distance to market is expected to have positive effect on amount of postharvest loss.

**Farm size (FRMSZ):** it is a continuous variable measured in terms of number of hectares of land owned by a farmer. It evaluates the effect of scale of operation on postharvest losses. Result obtained from Zenebe *et al.* (2015) showed that one-unit increment in banana land area could result in reduction of postharvest losses which might go against the notion that larger losses are possible with high output. It showed how farms might become more effective in minimizing losses through improved procedures as their level of operation grows. In contrast, Aidoo *et al.* (2014) reported that large farms generally produce higher output levels. However, when a household faces labor constraints, there is even a slight delay from traders, farmers often experience significant tomato losses. In this study, farm size will have negative effect on the amount of postharvest loss.

**Access to training (TRNG):** it is a dummy variable taking the value of one if a household got training and 0, otherwise. Access to training is essential for improving the efficiency, safety and sustainability of tomato market chain. Through training from agricultural offices, the majority of previously used agricultural practices were currently improving (Zelalem *et al.*, 2021). Abera *et al.* (2022) also found that the reduction in avocado postharvest loss was

caused by an improvement in training accessibility. Thus, in this study training will have negative effect on amount of postharvest loss.

**Insect pest infestation/rodents (INS):** it is a dummy variable 1 if farmers encountered postharvest loss during storage due to insects/rodents or 0 if they did not. According to Sisay (2022), damages by insect pests' infestation while storage has negatively and significantly affected the status of crops, implying that farmers facing loss due to insect infestation/rodent feedings are higher compared to those farmers who did not. Bezabih *et al.* (2017) also reported that at producers' level, insect pest and disease were the main reasons for postharvest loss which were primarily caused by inadequate insect pest control methods. In this study insect pest infestation/rodents is expected to have positive effect on the amount of postharvest loss.

**Storage problem (STRG):** it is a dummy variable with a value of 0 if producers face storage problems and 1 otherwise. Aidoo *et al.* (2023) reported that losses incurred were significantly increased by the length of time harvested tomato fruits were kept in storage until the point of sale. Given the time limited shelf life of tomatoes, this is compatible with an already existing expectation because tomatoes are very perishable. In this study storage conditions is expected to have positive effect on postharvest losses.

**Membership in cooperatives (MCOP):** it is a dummy variable that takes the value of 1 if the household are members of cooperatives, and 0 otherwise. It helps farmers to have access to information useful in production and marketing and enhance market participation. According to a study on banana postharvest loss conducted by Mulualem *et al.* (2015), farmers who were members of cooperatives were less likely to suffer postharvest loss as they have connections with traders who purchase their crops after harvest. Thus in this study membership in cooperatives is expected to have negative effect on amount of postharvest loss.

**Contact with extension agents (EXTCON):** this is measured as a continuous variable that is quantified by the number of times an extension agent visits a farmer in a given year. Abera *et al.* (2022) found that an additional day of engagement with an extension agent led to a reduction in postharvest loss of avocados. In a study of sesame postharvest loss, Desale *et al.* (2019) also found the same result: sesame grain postharvest loss decreased when the number of extension contacts on sesame production of the small-scale sesame growers increased by

one. Extension services are offered to help producers manage their production and handle problems allowing the control of postharvest loss possible. In this study contact with extension agents is expected to have negative effect on tomato postharvest loss.

**Access to credit (CRDT):** it is a dummy variable that takes on value of 1 if the farmer has access to credit and 0 otherwise. The ability of the farmer to get the essential inputs might be improved by access to credit, which would raise production. The more access farmers have to credit, the lower the level of postharvest loss they incur (Falola *et al.*, 2023). Same result was obtained by Benyam *et al.* (2018) on a study of potato postharvest loss. Access to credit is expected to have negative effect on tomato postharvest loss.

**Volume of tomato produced (Matomprod):** as production level rises, the pressure on storage, handling transportation and market systems increase highlighting the risk of losses. According to Falola *et al.* (2023) an increase in onion output has increased postharvest losses due to inadequate storage facilities. Moreover, labor intensive nature of timely harvesting may pose challenges for farmers, by exacerbating losses. Similarly, as the production area expands, the resulting increase in total output leads to greater postharvest loss of potatoes (Benyam *et al.*, 2018).

Table 2. Description of variables and hypothesis

<b>Variables</b>	<b>Measurement</b>	<b>Hypothesis</b>
<b>Dependent variable</b>		
Tomato postharvest loss among smallholder farmers	Continuous	
<b>Independent variable</b>		
Sex of the household head	Dummy	-
Age of the household head	Continuous	+/-
Education of the household head	Continuous	-
Family size	Continuous	-
Distance from main road	Continuous	+
Farm size	Continuous	-
Access to training	Dummy	-
Insect pest infestation/rodents	Dummy	+
Storage problem	Dummy	+
Membership in cooperatives	Dummy	-
Contact with extension service	Continuous	-
Access to credit	Dummy	-
Volume of tomato production	Continuous	+

Source: own calculation using survey data, 2024

## 5. RESULTS AND DISCUSSION

In this chapter, data's were analyzed using descriptive statistics and econometric models. In the descriptive section, actors involved in tomato market chain, socio-economic and demographic characteristics of sample farmers and performance of sampled farmers and traders are presented. The chapter also presents the econometric analysis on determinants of tomato postharvest loss among smallholder farmers.

### 5.1. Descriptive Statistics Analysis

#### 5.1.1. Descriptive statistics of continuous explanatory variables

The variables included under this section are the continuous explanatory variables such as age, total family size, farm size of tomato, extension contact and credit. By examining the mean, standard deviation, minimum and maximum values for these variables, a comprehensive overview of their distribution and variability within the data set has been discussed.

As indicated in Table 3 below, the average age of farmers was 36.56, with 24 being the minimum age and 65 being the maximum. According to the variable's result, all tomato farmers are within the range of productive age range, meaning they can actively engage in the production and marketing activities. This result aligns with that of Bezabih *et al.* (2017), who reported that the average age of producers was found to be 33 years, suggesting that younger farmers are more actively involved in tomato production than older once. The range of education spans from 1 to 15 years with a mean schooling year of 6.68. As it can be depicted in Table 3, the average family size of farmer households included in the study area was found to be 3.14. It has also been indicated that households with maximum family members to be 7.2.

The average land allocated for tomato in the study area is 0.29 ha. Land is one of the most significant factors of production in agriculture and a basic asset for farmers. In the production year, the minimum and maximum land allotted for tomato cultivation in the study area were 0.13 and 1 ha, respectively. This shows that the amount of land set aside for tomato cultivation in the study area was similar to that reported by Fentahun *et al.* (2019). The study revealed

that households in Fogera district of South Gondar Zone cultivated an average of 0.31 ha of lands for tomatoes, demonstrating the relative dominance of tomatoes over other vegetables (Table 3).

Table 3. Demographic characteristics of sampled households (continuous)

Variable	Mean	Min	Max	Sdv
Age (years)	36.56	24	65	8.88
Education (years)	6.68	1	15	3.11
Total family size (AE)	3.14	1	7.20	1.64
Farm size (ha)	0.29	0.13	1	0.14
Extension Contact	1.7	0	6	1.04
Distance	4.60	0.5	10	3.20

Source: Own calculation using survey data, 2024

Farmers interact with extension agents 1.7 times per month on average; there might be as little as 0 or as many as 6 interactions. This implies that some farmers might interact with extension agents on a regular basis, others might only interface with them sometimes or not at all, which could affect their ability to obtain information about best practices and other aspects of agriculture. Abera *et al.* (2018) discovered that a sample responder of tomato farmers received an extension service offer 1.05 days out of every month on average. As indicated in Table 3, the average distance from main road was 4.60km, while some are as close to 0.5km and as far as 10 km from the nearby market.

### 5.1.2. Descriptive statistics of dummy variables

The result presented in Table 4 shows that 163 (95.32%) of sample respondents in the study area were male headed while only 8 (4.68%) of the sample households were female headed. This indicates that men predominate in the study area when it comes to tomato production.

Table 4. Demographic characteristics of sample respondents (dummy)

Variables		Frequency	Percent (%)
Sex	Male	163	95.32
	Female	8	4.68
Access to credit	Yes	8	4.68
	No	163	95.32
Access to training	Yes	103	60.23
	No	68	39.77
Storage problem	Yes	149	87.13
	No	22	12.87
Membership of cooperatives	Yes	144	84.21
	No	27	15.79
Insect pest infestation	Yes	41	23.98
	No	130	76.02

Source: Own calculation using survey data, 2024

Increasing access to credit is one way of improving productivity and production among smallholder farmers. It is a prerequisite for farmers to buy purchase improved seed and fertilizer. However, according to Table 4, only 8 (4.68%) of the sample household had access to credit. This is due to the fact that majority of the farmers use the revenue they get from their livestock production.

Training on postharvest handling and storage is crucial to minimize loss, maintain quality and ensure product safety. In the study area, 60.23% of the respondents have access to training while 39.77% have no access. Table 4 shows that 87.13% of the respondents face storage problem of tomato. About 84.21% of the sample households were members of cooperatives while the rest were non-members.

Farmers frequently deal with insect pest infestation/rodents during tomato production. Table 4 demonstrates that 23.98% of respondents encountered insect pest infestations. Conversely, Sisay (2022) discovered that 87.78% of farmers have insect pest infestation/rodent feeding during storage of their crop which significantly greater proportion among farmers who experienced postharvest losses.

## 5.2. Market Chain Actors and their Role

From farmers to consumers, each participant plays a crucial role in ensuring tomatoes move efficiently from the field to the market place. The actors involved in the tomato market chain are discussed below:

**Producers:** producers are the initial participants, beginning with land preparation on their farm, sourcing inputs from external suppliers, and continuing through postharvest handling and marketing. All farmers grow tomatoes for the market and 98.83% grow tomato for both production and consumption.

Taking into account the resources at hand, producers choose what input to utilize, when to plant and harvest, how much to consume and how much to sell (Addisu, 2016). Table 5 shows that farmers produce tomato which they then sell to wholesalers (91.23%), retailers (17.54%), consumers (1.17%) and collectors (4.68%). As the link between tomato crops and various market channels, they are essential to the market chain.

Table 5. Distribution of tomato sales by buyer type

To whom	Frequency	Percent
Wholesalers	134	78.36.
Retailers	27	15.79
Consumers	2	1.17
Collectors	8	4.68

Source: Own calculation using survey data, 2024

**Wholesalers:** market participants that purchase tomatoes in bulk and resell them to other traders are known as wholesalers. They buy more tomatoes at the farm gate directly from farmers than any other marketing actor does from the village market. Retailers and urban consumers are the major tomato buyers from wholesalers. This distribution demonstrates how important wholesalers are to sustaining consistent flow of goods across several channels and guaranteeing that different market groups are suitably supplied (Appendix table 1). Farmers are the primary suppliers of tomato to wholesalers, who combine produce and distribute it to retailers and collectors. Wholesalers also obtain tomato from collectors (Appendix table 2).

**Collectors:** collectors play crucial role in agricultural market chain by gathering tomato produce directly from farmers for the purpose of reselling it to wholesalers and retailers. In the study area, wholesalers were the major buyers from collectors (Appendix table 1). Farmers serve as the primary suppliers of tomatoes to collectors followed by wholesalers (Appendix 2).

**Retailers:** these are traders that buy tomatoes from farmers wholesalers and other retailers then resell them to customers. In the chain that delivers tomatoes to consumers, this is one of the last connections. Urban consumers are the primary buyers from retailers in the study area (Appendix table 1). Wholesalers are the main suppliers of tomatoes to retailers followed by other retailers and farmers. Retailers mostly rely on wholesalers to benefit from the large purchasing power (Appendix table 2).

**Brokers:** brokers are intermediaries who arrange transactions between buyers and sellers, earning a commission for their role in the deal. In the study area, few wholesalers use brokers to purchase tomatoes from the farmers.

**Consumers:** consumers are individuals who buy goods and services for consumption without the intention of reselling them. They serve as the last link in the market chain. The primary suppliers of tomatoes to consumers in the study area are retailers (Appendix table 2).

### **5.3. Tomato Production and Postharvest Loss**

According to Wongnaa *et al.* (2014), tomatoes are essential for everyday meal preparation since they may be consumed fresh or cooked. Soups, juices, sauces, ketchups purees and pastes are made with larger with larger volumes. One of the main cash crops grown in Adea Woreda is tomato. All farmers grow tomatoes for the market and 98.3% grow tomato for consumption. This is in contrast with the results of Abdirizak (2018), which states that only 2.65% of the total amounts of tomato grown are used for consumption. Inputs, actors of tomato supply chain and their roles and sources of inputs are discussed in the following sections.

The postharvest losses in tomato production at the farm level indicate that the total loss occurring across different postharvest activities amount to 47.02 quintals per hectare. The different stages contributing to this loss include handling, storage, loading, grading packaging

and transportations. The highest postharvest loss in tomato production occurs in transportation, accounting for 30.48% of the total loss, equivalent to 14.33 quintals per hectare. This significance loss is primarily due to improper handling, overloading, lack of temperature control further exacerbate the problem, causing higher spoilage rates.

Following transportation, packaging losses rank second, making up 20.71% (9.74 quintals per hectare). Inadequate packaging materials and improper handling lead to fruit compression and exposure to extreme temperatures, accelerating spoilage. Handling losses account for 13.74%, with 6.46 quintals per hectare lost due to rough handling practices during harvesting, sorting and moving tomatoes. Mishandling results in bruising and increased susceptibility to postharvest diseases.

Similarly, storage losses contribute 12.95% (6.09 quintals per hectare) lost, mainly caused by poor storage conditions such as high temperatures, humidity and pest infestations. Inadequate storage facilities accelerate spoilage. Losses during grading amount to 12.19% with 5.73 quintals per hectare lost. This stage involves sorting tomatoes based on size, shape, and quality, leading to the rejection of damaged or lower quality fruits. While grading helps in maintaining market standards, improper sorting methods can lead to unnecessary losses. Loading losses are the lowest among all stages, contributing 9.93% of the total loss, with 4.67 quintals per hectare wasted.

Table 6. Estimates of tomato postharvest loss

Postharvest activities	Loss per hectare	Loss per quintal	Loss (%)
Handling	6.46	0.28	13.74
Storage	6.09	0.26	12.95
Loading	4.67	0.20	9.93
Grading	5.73	0.25	12.19
Packaging	9.74	0.42	20.71
Transporting	14.33	0.62	30.48
Total	47.02	2.03	100

Source: Own calculation using survey data, 2024

Due to their great nutritional content and adaptability in a variety of culinary applications, tomatoes are one of the most important vegetables consumed worldwide with significant economic impact. However, farmers in the study area face a significant challenge due to postharvest loss. The result in Table 7 reveals that limited access to market (77.78%), pest and

disease (70.76%) and poor handling and transportation (39.77%) are the main factors that contribute to tomato postharvest loss. According to Bezabih *et al.* (2017), postharvest losses were caused by a number of factors including disease, pest infestations, and a lack of market for produce that needed to be sold right away after harvest.

Table 7. Factors contributing to tomato postharvest loss

Factors	Frequency	Percent
Poor handling and transportation	68	39.77
Inadequate storage facility	37	21.64
Limited access to market	133	77.78
Lack of processing activities	35	20.47
Inefficient packaging	6	3.51
Lack of knowledge and training	22	12.87
Pest and disease	121	70.76
Perishability	2	1.17

Source: Own calculation using survey data, 2024

#### 5.4. Socioeconomic Characteristics of Sampled traders

This section entails the details of trader's demographic characteristics: a sample of 32 traders consisting 14 retailers, 5 wholesalers, 5 collectors and 8 consumers taken from the two *Kebeles* namely Godino and K'at'ila.

The survey indicated that out of the sample traders, 34.38% were female and 65.63% were male. Small-scale vegetable sales are primarily carried out by female traders. This implies that, women lack capital necessary to participate in vegetable wholesale, and most women find it difficult to engage this kind of trade activity since they need a great deal of involvement and networking (Bezabih *et al.*, 2017).

The result in Table 9 reveals that the mean age and trading experience of traders is 37.68 and 4.58 years implying that tomato traders in the study area are within economically active age group. Average family size of traders on the other hand consists of 3.09 individuals. As for education, the mean schooling year of traders is 5.46 years.

Table 8. Demographic characteristics of traders (continuous variables)

Variable	Mean	Sdv	Min	Max
Age	37.68	6.10	29	51
Family size	3.09	1.46	1	6
Education	5.46	3.61	1	12
Trade experience	4.58	2.74	1	12

Source: Own calculation using survey data, 2024

Financial capital is critical for traders since their degree of engagement in tomato marketing business depends on it. Table 10 indicated that the mean working capital of wholesalers, retailers and collectors is 292,000 ETB, 115,625 ETB and 62,000 ETB, respectively. From the minimum and maximum capital of traders, wholesalers take up the first place followed by retailers and collectors.

Table 9. Working capital of traders in ETB

Traders	Mean	Std. Dev.	Min	Max
Wholesalers	292,000.00	165,287.6	150,000.00	550,000.00
Retailers	115,625.00	46,278.08	13,450.00	200,000.00
Collectors	62,000.00	60,166.44	20,000.00	150,000.00

Source: Own calculation using survey data, 2024

## 5.5. Tomato Postharvest Loss at Traders Level

Postharvest loss of tomatoes varies among different market chain actors, occurring at different stages such as handling, packaging, storage, loading/unloading, transportation and distance. To quantify these losses, the percentage loss for each market chain was calculated by dividing the amount of tomato lost by the total amount of tomato purchased. This approach provides a clearer understanding of the extent of postharvest deterioration at different points in the market chain. The results highlight variations in loss levels among wholesalers, collectors and retailers, reflecting the impact of different postharvest activities of on tomato losses.

Wholesaler experience the lowest loss at 5.28% which occurs during bulk handling, storage, and transport. Since they deal with large quantities and often move tomatoes quickly, their losses remain relatively lower compared to other actors. Collectors, who gather tomatoes from

farmers and supply them to wholesalers or retailers experience a moderate loss of 12.76%. their losses occur during packaging, storage, and handling as they often lack proper facilities and efficient transport, leading to spoilage before the tomatoes reach the next stage in the market chain. Retailers, however, face the highest postharvest loss at 28.35% due to multiple factors. Tomatoes at the retail stage are frequently handled and repackaged, increasing the likelihood of mechanical damage. Additionally, retailers often store tomatoes for extended periods, making them more susceptible to spoilage. Exposure to unsuitable conditions such as heat, humidity and poor ventilation further exacerbates losses.

Table 10. Postharvest loss of tomatoes along market actors

Actors	Postharvest activities	% loss
Wholesalers	Handling, packaging, storage, load/unload, transportation	5.28
Retailers	Packaging, storage, load/unload, distance	28.35
Collectors	Packaging, storage, load/unload, distance	12.76

Source: Own calculation using survey data, 2024

## 5.6. Marketing Channels and Margin Analysis

### 5.6.1. Tomato marketing channels

- I. Producer-Consumer:** This channel accounted for 1.17% of the total tomatoes marketed during the survey period, representing the smallest share of tomato supplied to the market.
- II. Producer-Wholesaler-Consumer:** In this channel, producers sell directly to wholesalers in the study area. It represented 78.36% of the total tomato marketed in the study area during the survey period. It ranks as the primary channel in terms of volume.
- III. Producer-Retailer-Consumer:** This channel accounted 15.79% of the total tomato marketed in the study area during the survey period. In this channel, producers directly sell to retailers.

- IV. Producer-Collectors-Consumer:** The channel represented 4.68% of the total tomato marketed in the study area during the survey method. In this channel, producers directly sell to collectors.
- V. Producer-Wholesaler-Retailer-Consumer:** This channel accounted 8.33% of the total amount of tomato marketed in the study area. It is an extension of channel II where wholesalers buy tomatoes from producers and sell to retailers to consumers.
- VI. Producer-Collectors-Wholesaler-Consumer:** This is another channel which accounted for 12.5% of the total supply of tomato. In this channel, collectors buy tomatoes from producers then sell to wholesalers to consumers.
- VII. Producer-Collector-Wholesaler-Retailer-Consumer:** This channel accounted for 58.33% of the total supply of tomato marketed in the study area. In this channel, collectors buy directly from producers sell to wholesalers. Wholesalers then sell to retailers to consumers. This is the longest and second important channel in terms of volume.

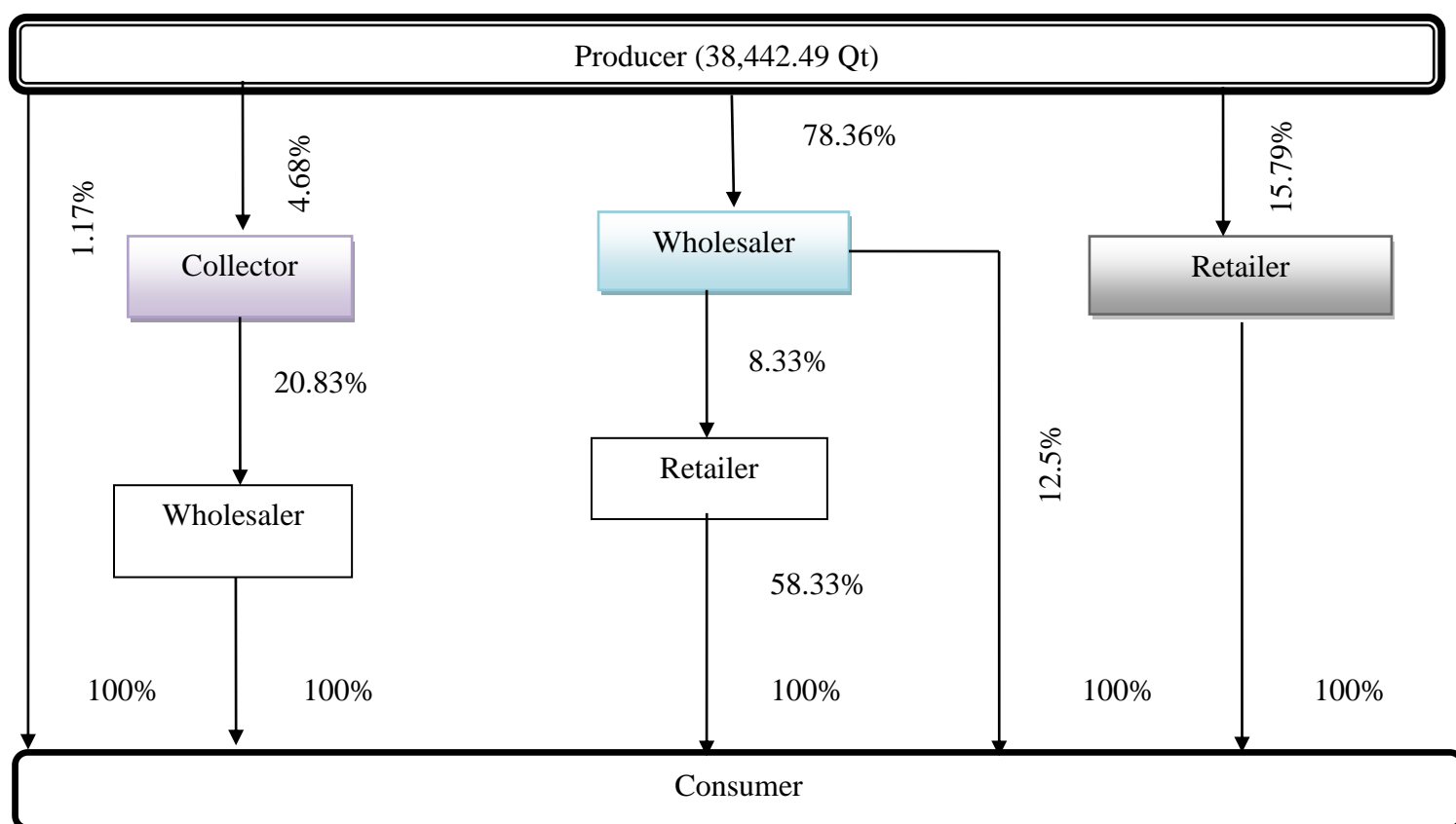


Figure 3. Tomato market channel

Source: Own sketch from survey result, 2024.

### 5.6.2. Marketing margin

In order to determine the margin, surveys on the price (payment) received or the selling price should be carried out concurrently with channel surveys. To determine the pertinent marketing margins with high accuracy two or three weeks of methodical pricing tracking at various market chain stages is needed (Pomeroy and Trinidad, 1995).

#### 5.6.2.1. Marketing cost

Marketing costs are calculated to determine the profit share captured by major actors in the marketing chain. As shown in Table 11, these costs were initially calculated in birr/quintal and later converted to total marketing cost. Retailers incurred the highest marketing cost at ETB 343.55 with transportation and tax costs being the major contributors. Collectors incur marketing costs of ETB 206.46 largely due to transportation and tax costs. Producers have a marketing cost of ETB 201.14 also primarily driven by load/unload, transportation and brokers. Wholesalers experienced the lowest marketing cost i.e. ETB 149.96.

Table 11. Costs along market chain actors per hectare (in Birr/qt)

Items	Producers	Collectors	Wholesalers	Retailers
<b>Production cost</b>	624.57	-	-	-
<b>Purchase price</b>	-	2,022.81	3,490.12	2,509.21
<i>Marketing cost</i>				
Packaging cost	2.33	2.91	6.2	6.49
Load/unload	33.5	12	19.05	17.86
Store rent	-	7.77	9.26	7.97
Transport	22.58	100	15.12	117.32
Tax	-	36.2	28.1	147.72
Brokers	28.82	0	9.77	1.65
Loss	113.91	35.78	60.03	20.46
Personal	-	11.8	2.44	24.08
<b>Total marketing cost</b>	201.14	206.46	146.96	343.55

Source: Own calculation using survey data, 2024

### **5.6.2.2. Marketing profit**

Table 12 illustrates a comprehensive breakdown of marketing channels for tomatoes for tomatoes, focusing on the roles and economic performance of various actors: producers, collectors, wholesalers and retailers. The analysis includes indicators such as production costs, losses, selling and purchase prices, marketing costs, market profits and gross marketing margins. It also determines each channels total gross marketing margin.

Producers achieve the highest profit of 2,751.64 birr/qt when selling to wholesalers (channels II), while the lowest profit is 1,284.33 birr/qt when selling to collectors (channels IV), through collectors to wholesalers to consumers (channels VI) and through collectors to wholesalers to retailers to consumers (channels VII). The GMM for producers indicates their share of the total marketing margin, with direct sales from producers to consumers showing a maximum of 100%, reflecting no additional intermediaries. Conversely, selling through collectors to wholesalers to retailers to consumers (channels VII) has the lowest GMM at 34.29%, indicating a reduced share of the final consumer price.

Collectors achieve a substantial market profit and significant shares of the marketing margin when selling to consumers (channels IV), through wholesalers to consumers (channels VI) and through wholesalers to retailers to consumers (channels VII). In the first two cases, they earn the highest profit of 5,036.04 birr/qt, while in the last channel it slightly decreases to 4,668.54 birr/qt. Their GMM is highest at 57.4% when selling through wholesalers to consumers (channels VI), followed by 48.35% when selling through wholesalers to retailers to consumers (channels VII) and 37.7% when selling directly to consumers (channels IV).

Wholesalers achieve a market profit of 5,459.39 birr/qt, when purchasing from producers and selling to consumers (channels II), while the profit is slightly higher at 5,460.04 birr/qt when purchasing from producers and selling through retailers to consumers (channels V) and through wholesalers to retailers to consumers (channels VII). When purchasing from collectors and selling to consumers (channels VI), the market profit is slightly lower at 5,458.96. The GMM varies significantly; reaching the highest at 37.78% when selling directly

to consumers (channels II) followed by 38.85% when selling through retailers then to consumers (channels V). In contrast, purchasing from collectors and selling to consumers (channels VI) and selling through retailers to consumer results in much lower GMM values of 6.53% and 6.23%, respectively. They reflect a reduced share of the final consumer price in these channels.

Retailers secure a market profit of 5,555.25 birr/qt in all three channels, despite variations in their purchase prices and marketing costs. The GMM differs notably, reaching the highest at 57.46% when purchasing from producers and selling to consumers (channels III) indicating a substantial share of the consumer price. In contrast, when purchasing from wholesalers and selling to consumers (channels V) or purchasing from collectors and wholesalers before selling to consumers (channels VII), the GMM drops to 4.98%. It reflects a reduced share of the final price retained by retailers in these channels.

As Table 12 indicated, the TGMM indicates the share of the total consumer price retained by all intermediaries combined. The highest TGMM, at 63.93%, occurs in the channels where tomatoes pass through collectors to wholesalers before reaching consumers (channels VI) highlighting significant intermediary involvement. In contrast, a TGMM of 37.7% is observed when tomatoes are distributed through collectors to consumers (channels IV), suggesting a more equitable distribution between producers and intermediaries.

Table 12. Marketing margin for different marketing actors (Birr/qt)

Actors	Indicators	Marketing channel						
		I	II	III	IV	V	VI	VII
Producers	Production cost	624.57	624.57	624.57	624.57	624.57	624.57	624.57
	Loss	113.91	113.91	113.91	113.91	113.91	113.91	113.91
	Selling price	3,265.95	3490.12	2,509.21	2,022.81	3,435.71	2,022.81	2,022.81
	Market profit	2,527.47	2,751.64	1,770.73	1,284.33	2,697.23	1,284.33	1,284.33
	GMMp (%)	100	62.22	42.54	38.58	58.24	36.06	34.29
Collectors	Purchase price				3,265.95		2,022.81	2,022.81
	Loss				35.78		35.78	35.78
	Marketing cost				170.68		170.68	170.68
	Selling price				5,242.5		5,242.5	4,875
	Market profit				5,036.04		5,036.04	4,668.54
Wholesale	GMMc (%)				37.7		57.4	48.35
	Purchase price		3,490.12			3,435.71	5,242.5	5,242.5

**(CONTINUED)**

	Loss	60.02		60.02	60.02	60.02		
	Marketing cost	89.94		89.94	89.94	89.94		
	Selling price	5,609.3 5		5,610	5,608.9 2	5,610		
	Market profit	5,459.3 9		5,460.0 4	5,458.9 6	5,460.0 4		
	GMMw (%)	37.78		36.85	6.53	6.23		
	Purchase price		2,509.2 1	5,610		5,610		
Retailers	Loss		20.46	20.46		20.46		
	Marketing cost		323.09	323.09		323.09		
	Selling price		5,898.8	5,898.8		5,898.8		
	Market profit		5,555.2 5	5,555.2 5		5,555.2 5		
	GMMr (%)		57.46	4.89		4.89		
TGMM (%)		-	37.78	57.46	37.7	41.74	63.93	59.47

Source: Own calculation using survey data, 2024

## 5.7. Determinants of Postharvest Loss of Tomato among Smallholder Farmers

In this section, careful consideration was given to the hypothesized explanatory variables in order to conduct a comprehensive analysis. The primary objective was to identify and understand the various factors that play a significant role in contributing to postharvest losses among smallholder farmers in the study area, specifically in relation to tomato production.

The analysis process involved a systematic evaluation of these variables to determine their individual and collective effects on postharvest losses. Statistical techniques and methodologies were employed to assess the strength of the relationships between explanatory variables and the observed losses. This allowed for the identification of significant contributors and helped to establish clearer understanding of the underlying factors.

By considering these explanatory variables, the study aimed to shed lights on the complex dynamics that contribute to postharvest losses among smallholder farmers in the study area. The findings would not only facilitate a better comprehension of the challenges faced by these farmers but also provide valuable insights for developing targeted interventions and strategies to mitigate tomato postharvest losses.

Overall, by incorporating the hypothesized explanatory variables, into the analysis, this section sought to uncover the factors that have a substantial impact on postharvest losses among smallholder farmers in the study area's tomato production, contributing to a deeper understanding of this critical issue and paving the way for effective solutions.

Multicollinearity and heteroscedasticity detection tests were carried out using the proper test statistics because the assumptions of the linear regression need to be true.

**Test of multicollinearity:** computing variance inflation factor (VIF) is a common method for identifying multicollinearity. High multicollinearity is frequently indicated by a VIF value greater than 10. The STATA command VIF was used to test for multicollinearity in the given explanatory variables. The findings showed that all VIF values were less than 10, which suggested that there was no significant multicollinearity issue (Appendix table 3).

**Test of heteroscedasticity:** Heteroscedasticity is a common problem observed in cross-sectional data resulting in invalid standard error. A problem with unexplained heteroscedasticity was discovered in the data set using the Breusch and Pagan STATA function. Therefore Robust OLS analysis with heteroscedasticity was therefore estimated in order to modify the problem in the presence of heteroscedasticity of uncertain form.

The goodness of fit of the model to explain the relationships between the predicted variables was demonstrated by the statistical significance of the model at 1% probability level. To evaluate the regression model's quality of fit, the coefficient of multiple determinations ( $R^2$ ) was used. Thus,  $R^2$  shows that the independent variables included in the model account for 69.77% of the variation observed in the dependent variable (postharvest loss of tomatoes).

Table 13. Determinants of postharvest loss of tomato among smallholder farmers (Robust)

Variables	Coeff.	Robust Std. Error	P
SEX	28.59226	18.14721	0.117
AGE_FAMSZ	.0672029	.0915888	0.464
EDU	2.193318	3.460965	0.527
FRMSZ	-111.2284	64.86342	0.088
TRNG	2.613322	9.873448	0.792
STRG	23.33899	25.87925	0.369
INS	135.8991	25.02551	0.000
DISMKT	-16.53648	3.347009	0.000
EXTCON	-12.07771	7.234792	0.097
CRDT	-99.72134	56.06563	0.077
MCOOP	17.15581	21.51056	0.426
Matomprod	-.0204098	.0835424	0.807
Constant	388.7326	60.83998	0.000
Number of observations	171		
Prob>F	0.0000		
F(12, 158)	53.62		
R-squared	0.6977		

Source: Own calculation using survey data, 2024

Insect pest infestations/ rodents: especially during postharvest period, insect pest infestation/rodents pose serious challenges to agricultural productivity. These biological threats have the potential to severely damage produce that has been preserved, costing farmers' significant amount of money. The result showed that insect pest has a positive effect on tomato postharvest loss at 1% significant level. This demonstrates that in the study area, a

significant increase in postharvest losses was linked to improper storage conditions, poor handling practice and less pest control methods. Tomato postharvest loss increases by 135.89 birr per quintal when farmers encounter insect and pest infestations. Sisay (2022), on the other hand who worked in most of the rural Ethiopia discovered that farmers who experience insect pest infestation/rodents face challenges than those who do not.

Access to credit (CRDT): For farmers, having access to credit is a crucial financial tool since it allows them to invest in inputs and better agricultural techniques that can increase yield and lower losses. According to the regression model's outcome, credit availability significantly and negatively affects tomato postharvest loss at 10% significant level, which is consistent with the hypothesis. Postharvest losses of tomato are reduced by 99.72 birr per quintal for farmers with credit access. This finding implies that credit availability plays a critical role in helping tomato farmers adopt sustainable agricultural techniques, improve their financial resilience and reduce postharvest losses. This is in line with Benyam *et al.* (2018) who found that credit access in Sheka Zone had significant and negative effect on postharvest losses of tomato.

Farm size (FRMSZ): farm size has a significant impact on agricultural production and efficiency since it frequently reflects the scope of operations and potential for resource use. The analysis revealed that at a 10% significant level, farm size has a negative relationship with postharvest losses of tomato. A one unit increase in tomato land size is linked to a decrease of 111.23 postharvest losses in birr per quintal. Large farms have an advantage in reducing postharvest losses, which maybe attributable to better resource allocation, better infrastructure and more effective management techniques. This outcome is consistent with the finding of Zenebe *et al.* (2015), which shows that a one unit increase in banana land size reduce postharvest loss. This is against the notion that more output results in higher losses. Aidoo *et al.* (2014), Goka *et al.* (2021), Falola *et al.* (2023) and Desale *et al.* (2019) reported that farm size of tomatoes, onions and sesame in Ghana, Togo, Nigeria and Kafta Humera district has positive and significant relationship with postharvest loss. Higher requirement of labor during harvesting and lack of proper storage facilities were the main reasons pointed out for the positive correlation with postharvest loss. However, farmers may reduce losses more effectively by using better strategies.

Distance from main road (DISMKT): the postharvest loss of tomato in birr per quintal is significantly and negatively impacted at 1% significant level by distance from main road. A one kilometer increase in distance between the farm and the market, results in a 16.53 birr per quintal decrease in postharvest loss of tomato. Farmers located farther from main roads often sell their tomatoes to collectors who travel to farms. Collectors typically assume responsibility for transportation and market delivery, minimizing the farmers' direct involvement in postharvest handling.

Contact with extension agents (EXTCON): contact with extension agents play a crucial role in disseminating agricultural knowledge and best practices to farmers, significantly impacting their productivity and efficiency. It affects postharvest loss negatively and significantly at 10% level, emphasizing the critical importance of extension services in reducing postharvest losses and enhancing agricultural outcome. Farmers who receive contact with extension services experience a reduction of 12.07 postharvest losses in birr per quintal. This is consistent with the findings of Abera *et al.* (2022) and Desale *et al.* (2019), who found that a decrease in avocado and sesame postharvest loss in Wolayita and Kafta Humera districts caused an increase in extension agent involvement per day.

## 6. SUMMARY, CONCLUSION AND RECOMMENDATION

### 6.1. Summary and Conclusion

Postharvest loss is a critical issue affecting the agricultural market chain, with significant implications for farmers, traders and other market actors. In districts like Adea, known for its agricultural potential in vegetable production, addressing postharvest loss is essential for enhancing profitability and sustainability. This study was conducted to identify market chain actors of tomato and their loss, examine the effect of tomato postharvest loss on profitability of market chain actors and identify the determinants of postharvest loss of tomato among smallholder farmers in Godino and K'at'ila *kebeles* of Adea district.

Both primary and secondary sources of data were employed in order to satisfy the study's specific objectives. Through observation and questionnaires, 171 randomly selected tomato producing households as well as 32 sample traders including, 5 wholesalers, 14 retailers, 5 collectors and 8 consumers provided the primary data. Secondary data was collected from published and unpublished sources as well as agricultural offices.

Data analysis for this study included descriptive statistics (frequency, mean, minimum, maximum and standard deviation), gross margin and econometric models. Multiple linear regression models were employed to determine the variables influencing smallholder farmers' tomato postharvest loss. The results are summed up as follows.

The major actors involved in tomato market chain include input suppliers, producers, wholesalers, retailers, collectors and consumers. Producers sell majority of the produce to wholesalers followed by retailers, collectors and consumers.

About seven different market channels of tomato were identified in the study area. Producers achieve the highest profit (2,751.64 birr/qt) when selling to wholesalers (channel II) and the lowest (1,284.33 birr/qt) when selling through collectors to wholesalers to consumers (channel VI) or through collectors to wholesalers to retailers to consumers (channels VII). The GMM or producers is highest (100%) in direct sales to consumers and lowest (34.29%) in channel VII. Collectors earn the highest profit (5,036.04 birr/qt) when selling directly to consumers

(channel IV) or through wholesalers (channel VI), while their GMM peaks at 57.4% when selling to wholesalers to consumers (channel VI). Wholesalers achieve maximum profit (5,460.04 birr/qt) when selling to retailers to consumers (channels V) and when selling to retailers to consumers (channel VII), with the highest GMM (38.85%) in channel V and the lowest (6.23%) in channel VII. Retailers secure a stable profit (5,555.25 birr/qt) across channels, with the highest GMM (57.46%) in direct sales to consumers (channel III) and the lowest (4.98%) in channels V and VII. The total gross marketing margin (TGMM) is highest (63.93%) in channel VI indicating significant intermediary involvement, while the lowest (37.7%) when collectors purchase from producers (channel IV) suggests a more balanced distribution between producers and intermediaries.

Postharvest losses in tomato production amount to 47.02 quintals per hectare, with transportation contributing the most (30.48%), followed by packaging (20.71%), handling (13.74%), storage (12.95%), grading (12.91%) and loading (9.93%). Key factors include improper handling, inadequate packaging, poor storage conditions and inefficient sorting, leading to significant spoilage. Among market actors, wholesalers have the lowest losses (5.28%) due to bulk handling and storage and transportation, while collectors experience moderate losses (12.76%) from packaging, storage and transportation. Retailers face the highest losses (28.35%) due to frequent handling, packaging, prolonged storage and exposure to unsuitable conditions like heat and humidity.

Multiple linear regression model (robust) was conducted to ascertain the determinants of postharvest losses of tomatoes among smallholder farmers. The results indicated that out of thirteen explanatory variables included in the model, five variables significantly affected tomato postharvest losses. While insect pest infestation/rodents significantly and positively affected tomato postharvest loss, access to credit, extension contacts, farm size and distance from main road significantly and negatively affected postharvest loss of tomato in birr per quintal.

## 6.2. Recommendations

Based on the comprehensive assessment of tomato postharvest loss within the market chain of Adea district, particularly in Godino and K'at'ila *kebeles*, several areas of improvement have been identified.

- Targeted interventions at each stage of the market chain to reduce postharvest losses are needed. Enhancing handling, storage and transportation practices can significantly mitigate losses, thereby improving the efficiency and performance of all actors involved in the tomato market chain.
- Adopting standardized, durable crates instead of traditional sacks to prevent compression damage. Policies should support affordable access to improved packaging materials.
- Policies should promote affordable climate-controlled storage solutions, particularly for collectors and retailers, to reduce spoilage caused by heat, humidity, and pests. Strengthening farmer-to-retailer linkages and encouraging timely sales can also help mitigate these losses.
- Policies should prioritize the development of efficient logistics and transportation networks to lower transportation and loading/unloading costs at farm level.
- Promoting training on hygienic and careful handling during harvesting and sorting to minimize the risk of pest infestations helps reduce damage to stored tomato crops by insect pest and rodent feedings.
- For future research, researchers should focus on the seasonality of tomato production, as opposed to relying on annual data, as done in this study. Given that tomatoes are seasonal crops, analyzing production and postharvest losses within distinct seasonal cycles could provide more accurate insights and allow for better informed interventions in managing losses.

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## 8. APPENDICES

### Appendix 1. Major buyers of tomato

Major buyers	Types of traders			Total	Percent
	Retailers	Wholesalers	Collectors		
Wholesalers	0	0	5	5	20.33
Retailers	0	2	0	2	8.33
Urban consumers	14	3	0	17	70.83
<b>Total</b>	<b>14</b>	<b>5</b>	<b>5</b>	<b>24</b>	<b>100.00</b>

Source: Own calculation using survey data, 2024

### Appendix 2. Major sellers of tomato

Major suppliers	Types of traders				Total	Percent
	Retailers	Wholesalers	Collectors	Consumers		
Wholesalers	8	0	1	0	9	28.13
Collectors	0	2	0	0	2	6.25
Retailers	3	0	0	8	11	34.38
Farmers	3	3	4	0	10	31.25
<b>Total</b>	<b>14</b>	<b>5</b>	<b>5</b>	<b>8</b>	<b>32</b>	<b>100.00</b>

Source: Own calculation using survey data, 2024

### Appendix 3. Conversion factor used for adult equivalent

Age category (years)	Male	Female
<10	0.6	0.6
10-13	0.9	0.8
14-16	1	0.8
17-50	1	0.8
>50	1	0.7

Source: Storck *et al.* (1991)

### Appendix 4. Conversion factor for Total livestock holding (TLU)

Types of livestock	TLU
Cattle	1
Camel	1.4
Sheep	0.1
Goat	0.1
Donkey	0.7
Poultry	0.01
Hives	1

Source: Storcket *al.* (1991)

## Appendix 5. Test for multicollinearity

. vif

Variable	VIF	1/VIF
Matomprod	2.58	0.386928
FRMSZ	2.55	0.392471
DISMKT	2.47	0.405050
EDU	2.15	0.465835
INS	2.13	0.469525
AGE_FAMSZ	1.69	0.593285
EXTCON	1.33	0.752999
STRG	1.21	0.824623
TRNG	1.17	0.858295
SEX	1.12	0.891401
CRDT	1.07	0.930901
MCOOP	1.05	0.953915
Mean VIF	1.71	

Source: Own calculation using survey data, 2024

## Appendix 6. Determinants of postharvest loss of tomato (Robust)

Variables	Coeff.	Robust Std. Error	P
SEX	28.59226	18.14721	0.117
AGE_FAMSZ	.0672029	.0915888	0.464
EDU	2.193318	3.460965	0.527
FRMSZ	-111.2284	64.86342	0.088
TRNG	2.613322	9.873448	0.792
STRG	23.33899	25.87925	0.369
INS	135.8991	25.02551	0.000
DISMKT	-16.53648	3.347009	0.000
EXTCON	-12.07771	7.234792	0.097
CRDT	-99.72134	56.06563	0.077
MCOOP	17.15581	21.51056	0.426
Matomprod	-.0204098	.0835424	0.807
Constant	388.7326	60.83998	0.000

Number of observations	171
Prob>F	0.0000
F(12, 158)	53.62
R-squared	0.6977

**Note:** Dependent variable is amount of tomato postharvest loss. \*\*\*, \*\* and \* are statistically significant at 1%, 5% and 10%, respectively.

Source: Own calculation using survey data, 2024

#### Appendix 7. Heteroscedasticity test for continuous explanatory variables

```
. hettest
```

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of PHL

chi2(1) = 34.43

Prob > chi2 = 0.0000

Source: Own calculation using survey data, 2024

#### Appendix 8. Demographic characteristics of continuous variables

```
. summarize AGE EDU FAMSZ FRMSZ TLU DISMKT EXTCON
```

Variable	Obs	Mean	Std. Dev.	Min	Max
AGE	171	36.5614	8.889553	24	65
EDU	171	6.573099	3.327105	0	15
FAMSZ	171	3.14269	1.646884	1	7.2
FRMSZ	171	.2909357	.145919	.125	1
TLU	171	6.043158	3.743463	0	20.6
DISMKT	171	4.604386	3.20248	.5	10
EXTCON	171	1.707602	1.049874	0	6

Source: Own calculation using survey data, 2024

## Appendix 9. Demographic characteristics of categorical variables

```
. tabulate SEX
```

Sex of the household head	Freq.	Percent	Cum.
Female	8	4.68	4.68
Male	163	95.32	100.00
Total	171	100.00	

```
. tab TRNG
```

Access to training	Freq.	Percent	Cum.
Yes	103	60.23	60.23
No	68	39.77	100.00
Total	171	100.00	

```
. tab STRG
```

Storage problem	Freq.	Percent	Cum.
Yes	149	87.13	87.13
No	22	12.87	100.00
Total	171	100.00	

```
. tab INS
```

Insect pest infestation /rodents	Freq.	Percent	Cum.
Yes	41	23.98	23.98
No	130	76.02	100.00
Total	171	100.00	

```
. tab CRDT
```

Access to credit	Freq.	Percent	Cum.
Yes	8	4.68	4.68
No	163	95.32	100.00
Total	171	100.00	

```
. tab MCOOP
```

Membership in cooperatives	Freq.	Percent	Cum.
Yes	144	84.21	84.21
No	27	15.79	100.00
Total	171	100.00	

Source: Own calculation using survey data, 2024

## Appendix 10. Survey questionnaire

**Survey Questionnaire**

My name is Hanna Tegegne. I am writing a thesis entitled “Tomato market chain and postharvest loss in Adea district, East Shewa Zone, Oromia National Regional State, Ethiopia” in partial fulfillment for MSc in Agribusiness and value chain management. The general objective of this study is to assess tomato postharvest loss along market chain. Confidentially this research will have significance in reducing postharvest loss along market chain actors. Therefore, your valid contribution by giving accurate information is highly valuable in achieving the objective of this research. The information to be collected will serve only for academic purpose and will be kept confidential. Thus, please feel free to convey the required information.

Thank you in advance for your cooperation

**A. Farmers questionnaire****I. Farmers general and demographic characteristics**

1. Name of household head: \_\_\_\_\_
2. Sex of household head(put ‘√’ mark on the box:    1.  Male    0.  Female
3. Age of the household head: \_\_\_\_\_ Years\*
4. Marital Status (√): 1.  Single 2.  Married 3.  Divorced    4.  Widowed
5. Family size: \_\_\_\_\_

Age	Male	Female
0-10		
11-13		
14-64		
>64		

6. Level of education of household head: \_\_\_\_\_ years\*

**II. Farm characteristics of the household head**

1. Do you have your own land for production (√)? 1.  Yes    2.  No

Crop	Land size
Onion	
Potato	
Tomato	
Cabbage	
Other(specify):	

### III. Tomato production and input used by the household head

1. Have you ever used agricultural inputs (✓)? 1.  Yes                      2.  No
2. If your answer is no, what's your reason? \_\_\_\_\_
3. If your answer is yes, what inputs have been used for tomato production and cost of inputs during 2023 production season?

Type of input	1=yes; 2=No	Sources <sup>*</sup>	Amount used (kg/No./basket)	Value(birr)	1=Cash; 2=Credit
Seed					
DAP					
Urea					
Crop residue					
Compost					
Labor					
Land rent					
Irrigation					
Machinery					
Insecticides/pesticides					
Others(specify)					

<sup>\*</sup>1= Own/family stock or production   <sup>\*</sup>2= Local markets   <sup>\*</sup>3= Research centers   <sup>\*</sup>4= Fellow farmers   <sup>\*</sup>5= Cooperatives   <sup>\*</sup>6= other (specify)

4. Do you get inputs for tomato production at the right time (✓)? 1.  Yes                      2.  No

### IV. Livestock production

Type of livestock	Total number	Annual income from Livestock
Cattle		
Camel		
Sheep		
Goat		
Donkey		
Poultry		
Hives		

### V. Market aspect

1. Have you sold vegetables before (√)? 1.  Yes                      2.  No
2. What type of vegetable crops do you produce? Amount of production during 2023?

Vegetable type	Quantity Produced (qt)	Quantity Consumed(qt)	For seed	Postharvest loss (in quintal)	Quantity sold(qt)	Average selling price(birr/qt)
Onion						
Potato						
Tomato						
Cabbage						
Others (specify)						

3. How much and to whom did you sell your produce?

Vegetable type	Amount sold(qt)	To Whom	Where
Tomato			1. Wholesalers 2. Retailers 3. Consumers 4. Collectors 5. Hotels 6. Processors
			1. Local market 2. District market 3. Adama 4. Addis Ababa 5. Others (specify)

			7. Others (specify)		
--	--	--	------------------------	--	--

4. In deciding to whom to sell, what factors did you consider?(√) (multiple response is possible)

1.  Transport availability      2.  Price      3.  Fairness of scaling  
4.  Closeness in distance      5.  Other (specify): \_\_\_\_\_

5. Do you have your own transportation facility? (√): 1.  yes      2.  No

6. What mode of transport do you often use while transporting tomato? (√)(multiple response is possible)

1.  Vehicles      2.  Manpower      3.  Pack animals  
4.  Cart      5.  Other (specify): \_\_\_\_\_

7. Average return of tomato in 2023

Crop type	Selling price (birr/qt)	Total cost (birr/qt)							
		Packing material	Loading/unloading	Transport	Broker	Damage/loss	Store rent	Tax	Others
Tomato									

8. Who sets your selling price for tomato? (√):

1.  Yourself      2.  Buyers      3.  Negotiations      4.  Set by demand and supply  
5.  Other (specify): \_\_\_\_\_

9. What do you think are the main factors that contribute to postharvest losses in your tomato production? (√) (multiple response is possible)

1.  Poor handling and transportation      2.  Inadequate storage facility  
3.  Limited access to market      4.  lack of processing activities

5.  inefficient packaging    6.  lack of knowledge and training    7.  pests and diseases    8.  Other (specify): \_\_\_\_\_
10. Did you take training on postharvest handling and storage facilities in 2023? (✓):  
1.  Yes    2.  No
11. What was the extension advice specifically on Vegetables production? (✓) (Multiple response is possible)  
1.  Seed bed preparation    2.  Fertilizer (compost) applications  
3.  Harvesting    4.  Transplanting    5.  Marketing of vegetables  
6.  Post-harvest handling    7.  Others (specify) \_\_\_\_\_
12. Is storage of tomato production a problem for you? (✓) 1.  Yes    2.  No
13. Did you encounter insect pest infestation/rodents during storage? (✓)  
1.  Yes    2.  No
14. If your answer is yes, what do you think are the reason? (✓) (multiple response is possible)  
1.  Improper storage method    2.  Inadequate knowledge of pest control methods  
3.  Poor sanitation    4.  Inconsistent temperature and humidity levels
15. Distance from main road: \_\_\_\_\_; walking minutes \_\_\_\_\_ hrs.

#### **VI. Contact with extension service**

16. Did you have extension contact in relation to vegetables production in the 2023 cropping season?(✓): 1.  Yes    2.  No
17. If yes, how often does the extension agent contacted you? \_\_\_\_\_per month/year
18. Who provides the advisory service? (✓) (Multiple response is possible)  
1.  Development agents    2.  NGOs (specify)    3.  Research centers (specify)  
4.  Others (specify) \_\_\_\_\_

#### **VII. Access to credit**

1. Did you take formal credit in 2023 cropping season? (✓): 1.  Yes    2.  No
2. If yes have you received credit in 2023 for vegetable production purpose? (✓)  
1.  Yes    2.  No

3. If yes, how much did you take for vegetable production purpose? \_\_\_\_\_birr
4. For what purpose did you take the credit in relation to vegetable production? (✓):
1.  Fertilizer
  2.  Seed for tomato
  3.  to purchase animal
  4.  to rent land for tomato production
  5.  to pay tax
  6.  Other (specify): \_\_\_\_\_
5. From whom did you get credit for vegetable production? (✓):
1.  Bank
  2.  NGO
  3.  Microfinance institution
  4.  Traders
  5.  Peasant associations
  6.  Other (specify)

### VIII. Membership in cooperatives

1. Are you a member of any cooperatives? (✓): 1.  Yes 2.  No
2. If your answer is yes, what is the name of the cooperative? \_\_\_\_\_
3. What services do you get from the Cooperative you belong to? (✓): (Multiple responses are possible)
  1.  credit
  2.  Seeds
  3.  Fertilizer
  4.  Education/information
  5.  Market
  6.  Other (specify) \_\_\_\_\_

### B. Trader's questionnaire

#### I. General Information

1. Age: \_\_\_\_\_
2. Sex (✓): 1.  Male 0.  Female
3. Level of education: \_\_\_\_\_years\*
4. Marital status (✓): 1.  Single 2.  Married 3.  Divorced 4.  Widowed
5. Total family size: \_\_\_\_\_
6. Major business you are engaged in (✓): 1.  Wholesaler 2.  Urban assembler
  3.  Retailer
  4.  Collector
  5.  Broker
  6.  Other (specify): \_\_\_\_\_
7. For how long have you been in the business? \_\_\_\_\_years
8. When did you do your business? (✓):
  1.  Year round
  2.  When purchasing price was low (high supply)

3.  When the demand for tomato was high                      4.  Once in a week

5.  Others (specify): \_\_\_\_\_

9. Trading experience: \_\_\_\_\_ year\*

## II. Financial capital

1. What was your initial capital when you started the business? \_\_\_\_\_ birr\*

2. How much was the amount of your working capital in 2023? \_\_\_\_\_ birr\*

3. What was the source of your working capital? (✓): 1.  Own saving 2.  Loan 3.

Gift                      4.  Share                      5.  Other (specify): \_\_\_\_\_

## III. Purchasing and Selling practice

1. Amount of tomato you purchased in 2023? \_\_\_\_\_ Qt.

2. Amount of tomato you sold in 2023? \_\_\_\_\_ Qt.

3. Who purchase tomato for you? (✓): 1.  Myself    2.  Friends    3.  Through brokers

4.  Family members    5.  Commission agents    6.  Others (specify): \_\_\_\_\_

4. Who were your major buyers? (✓): 1.  Wholesalers    2.  Retailers

3.  Millers/processors    4.  Urban assembler    5.  Urban consumer

6.  Government organizations                      7.  Others (specify): \_\_\_\_\_

5. Who were your major suppliers? (✓): 1.  Wholesalers    2.  Village collectors    3.

Retailers                      4.  Urban assemblers    5.  Farmers                      6.

Government organizations    7.  Others (specify): \_\_\_\_\_

6. On average, how many markets do you visit in a week? \_\_\_\_\_ markets\*

7. How is your usual purchasing price compared to your competitors? (✓):

1.  Higher    2.  Lower    3.  The same

8. If it was higher in Q. 7, what was the main reason?(✓):

1.  To attract more suppliers

2.  To buy more quantity                      3.  To get better quality tomato

4.  To kick out competitors from the market                      5.  Others

(specify): \_\_\_\_\_

9. Who sets the purchase price of tomato in the market? (✓): 1.  Myself

2.  The seller    3.  set by the market force    4.  Negotiation with suppliers

5.  By Discussing with other traders

10. Who sets the selling price of tomato in the market?(√): 1.  Myself 2.  Set by the market force 3.  Buyers 4.  Other (specify): \_\_\_\_\_
11. If you set the selling price in Q. 10, when do you set the selling price?(√):  
1.  In the morning before market day 2.  One day before the market day  
3.  At the time of selling 4.  Others (specify): \_\_\_\_\_
12. How was the supply of tomato in 2023 compared to the previous year?(√):  
1.  Increased 2.  Decreased 3.  No change
13. How was the price of tomato in 2023 compared to the previous year? (√):  
1. Increased 2. Decreased 3. No change
14. What is your mode of buying and selling strategy?(√):  
1.  in cash 2.  In credit 3.  Combining both cash and credit
15. What is the major problem to enter tomato trade?(√):  
1.  License 2.  Lack of starting capital 3.  Government policy  
4.  Trading experience 5.  Other (specify): \_\_\_\_\_
16. Are there restrictions imposed on unlicensed traders? (√): 1.  Yes 2.  No
17. What are the main criteria's to be licensed tomato traders?(√): 1.  Initial capital  
2.  Interest 3.  Tomato trading experience  
4.  Others (specify): \_\_\_\_\_
18. How much birr is required to get the license? \_\_\_\_\_ birr\*
19. What mode of transportation you often use to transport tomato from purchasing sites to selling market? (√): 1.  Head loading 2.  Pack animals 3.  Animal cart  
4.  Trucks 5.  Other (specify): \_\_\_\_\_
20. Loss: \_\_\_\_\_ qt ; \_\_\_\_\_ Birr
21. Cost incurred in the trading process

Marketing cost component in the chain (ETB)	Product: Tomato
Selling price	
Packaging material	
Loading/unloading	
Store rent	
Transportation	
Tax	

Broker	
Personal travel and other expenses	
Other costs	
Total	

**IV. Problems with sale and purchase of tomato (prioritize);**

Product	Problem related to Purchase	Problem related to sale
Tomato		

Problem related to purchase(√)(multiple responses are possible):

1.  Non reliable supply of tomato
2.  seasonal supply of tomato
3.  High purchasing price per unit of tomato
4.  Poor quality of tomato due to handling
5.  Perishability of the product
6.  Interference of brokers
7.  Other (specify): \_\_\_\_\_

Problem related to sale (√) (multiple responses are possible):

1.  Non reliable demand for tomato
2.  High loss due to quality deterioration during transaction
3.  Low selling price of tomato
4.  Other (specify): \_\_\_\_\_