UNIVERSITY OF LUSAKA

School of Postgraduate Studies

Managing Food Loss and Waste: Case Study of Granadilla Production at Everglades Farm, Mkushi

A Dissertation Presented in Partial Fulfilment for the requirement of the program

Master of Science in Procurement, Logistics and Supply Chain Management

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DECLARATION

I declare that the work in this thesis titled “Food Waste Management Strategies in the Food Supply Chain: A case Study of Everglades Farm in Mkushi” is my work. The information derived from the literature has been duly acknowledged in the body of the work and in the references provided. No part of this thesis was previously presented at this University.

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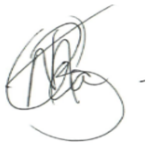
Signed: 

Date: 16th January 2025

Supervisor: Dr Shem Sikombe

Signed: 

Date: 20.03.2025

DEDICATION

This thesis is dedicated to my parents and my brother who have lovingly supported me throughout this process and for the sacrifices they have made.

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I would first and foremost like to thank God, for giving me the opportunity to complete this chapter of my university journey. He has been faithful to his word in Isaiah 41:13, holding my hand and helping me with each step in my course. If not for Him I would not have gotten this far.

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ABSTRACT

Food loss (FL) and waste pose economic challenges in agricultural supply chains, particularly in fresh fruit chains like the granadilla. In the fruit supply chain (SC), significant losses occur at various stages of the SC, leading to high levels of waste and limited profitability. This thesis investigates FL and waste in a Granadilla SC based on a Farm in Mkushi Zambia, focusing on production to distribution stages. The objective of this study is to investigate the causes and impacts of FL and waste in Everglade's Granadilla supply chain. This thesis used a case study approach paired with a concurrent triangulation design. The qualitative data was collected by interviewing five key respondents who are critical to the operations in each stage of the SC. Additionally, the quantitative data was collected through secondary sources, using data previously gathered by the company, and analysed using the Additionally, United Nations Economic Commission for Europe measuring methodology. Results indicated that the production stage of the SC accounts for the highest stage of FL due to wind damage and pests and diseases. These issues cause a snowball effect eventually causing the fruit to be deemed unexportable. The processing stage exhibits moderate losses primarily from quality issues. These losses reduce the farm's export profitability and capacity. It was found that approximately 25% of the granadilla loss occurred at the production stage, amounting to an estimated K4,227,810.00 per season (at K30/kg). A further 26% was lost at the processing stage, and 9% was lost during distribution. Thus, the study highlights the need for strategic intervention, such as utilising the theory of constraints to identify constraints in the SC and work towards improving those constraints. This would mean, identifying the constraint – such as focusing on pests and diseases, exploiting the constraint - exploring and undertaking pest and disease management practices, subordinating other processes – allocating workers for pest scouting and treatment during high-risk months, elevating the constraint – investing in disease-resistant granadilla varieties such as the yellow granadilla (Passiflora edulis f. flavicarpa) and repeating the process with other constraints. Additionally, it was recommended that the farm works towards diversifying its income through the introduction of value-added products such as juices, jams and other granadilla-relevant products. This research contributes to understanding the food supply chains and food loss in sub-Saharan Africa and offers insights for agricultural stakeholders.

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LIST OF ACRONYMS

FAO - The Food and Agriculture Organization of the United Nations

FL – Food Loss

FSC – Food Supply Chain

FW – Food Waste

GDP – Gross Domestic Product

SC – Supply Chain

UK – United Kingdom

UNECE – United Nations Economic Commission for Europe

I. CHAPTER 1: INTRODUCTION

1.1. THE BACKGROUND

Food loss (FL) and food waste (FW) have been growing global issues that have garnered the attention of both governments and companies worldwide. According to Balci and Tuna (2020), approximately 1.6 billion tons of food is wasted annually, which amounts to a value of approximately $1.2 trillion.

FL refers to the food that is lost at various stages of the supply chain (SC) before it reaches consumers (Brennan and Browne, 2021). FW refers to food losses that occur at the end of the food supply chain (FSC) specifically at the consumption and retail stages of the SC, as shown in Figure 1 (Brennan and Browne, 2021).

There are five different stages of the FSC: Production, Post-harvest, Processing, Retail and Consumption. FL occurs in the production, post-harvest, and processing stages of the SC, and FW occurs in the retail and consumption stages.

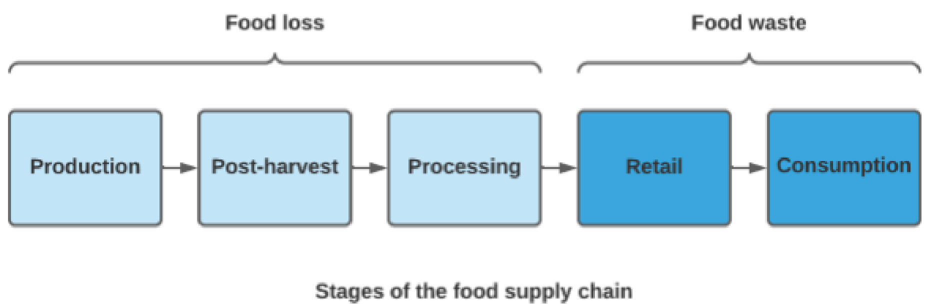

Figure 1: Stages of the Food Supply Chain (Brennan and Browne 2021)

Fruits and vegetables are foods particularly prone to major FL and FW. Their high perishability and short shelf life, make them vulnerable to losses throughout their supply chain. According to Seraina et al. (2023), roughly 20-50% of all produced vegetables and fruits are wasted along the SC before reaching the consumer. There are different causes for FL such as improper handling of food post-harvest, mismanagement of the cold chain and improper packaging (Seraina et al. 2023). As for global supply chains, causes for FL include delayed operational processes, unfavourable weather conditions or disruptions such as COVID-19 (Seraina et al.

2023). One fruit whose FL will be studied in this thesis is the granadilla. Granadillas also known as passion fruits, are widely enjoyed in various parts of the world, including Africa, Latin America, and Asia. The fruit is highly known and used for its pulp, which is rich in vitamin A and vitamin C, dietary fibre and antioxidants, making it a popular ingredient in variety of ways and items, such as raw consumption or processed into ice cream, juice, jams, and snacks. In addition, to its nutritional benefits, granadillas contribute to economic development by providing income to farmers through distribution and sales to both the local and export markets.

In Zambia, the granadilla market is slowly expanding, for instance in regions like Mkushi. To protect the data and identity of the farm, a pseudonym will be used: Everglades Farm. Everglades Farm is one of the farms that has been growing granadillas for approximately nine years. They typically grow their granadillas between August and June, harvesting an average of 558,000 kilograms (kg) per harvest. Everglades produces granadillas mainly for the export market. The farm's operations include planting and growing the granadillas, harvesting them, packing the fruit into plastic crates, and sending them to the pack shed. The pack shed is owned by a different farm, Sando Farm (A pseudonym). At Sando Farm, the fruit is stored in cool rooms and sorted. The “good” fruit is further sorted into export-quality fruit and fruit that can be sold on the local limited market. Once this is done, the fruit designated for export is placed on a truck, transported to the airport, and sent to different markets, such as the UK, France, and Canada, while the local fruit is sent to the local market, with the local market being the smaller/limited market.

However, Everglades Farm’s granadilla SC faces several significant challenges that have impacted its overall profitability and efficiency. One of the primary issues is FL, which occurs at various stages of the SC, from production through to distribution. This waste not only reduces the amount of marketable fruit but also increases costs, particularly when considering storage costs, handling costs, and disposal costs. As a result, the profitability of Everglades Farm has been considerably affected, with wasted resources eating into margins and reducing the farm’s potential revenue.

Addressing these challenges is essential for improving SC efficiency and enhancing the profitability of the business. Solutions that reduce waste, streamline operations, and increase the quality and consistency of the product can provide long-term benefits.

Optimizing the SC can also help in reducing costs associated with handling and storage, which would significantly improve the farm's competitive edge in the market.

This thesis will undertake a comprehensive case study of Everglades Farm's granadilla SC, aiming to identify key inefficiencies and propose actionable strategies for improvement. By thoroughly examining the operations and dynamics of the granadilla SC, this research intends to uncover insights that could lead to more sustainable agricultural practices and contribute to the optimization of the SC. Additionally, the findings aim to strengthen the value chain for this economically significant crop for Everglades Farm.

1.2. STATEMENT OF THE PROBLEM

Granadillas have a significant market presence in countries such as the United Kingdom (UK), with granadilla imports valued at approximately $8.7 million in 2009 (US Aid, 2011), and upwards of $116.8 million in 2023 (Tridge, 2024). In Germany, the granadilla imports were valued at $260 million, while France's granadilla imports were valued at $217.7 million in 2023 (Tridge, 2024).

As has been mentioned, this case study focuses on Everglades Farm in Mkushi, who grow, sell, and export granadillas to the European market, including the UK, Canada, Germany, and France. However, the farm experiences significant FL along the SC, with the greatest loss occurring at the production stage of the SC. These losses reduce the number of granadillas that can be exported, limiting the ability to capitalise on the demand in the European market and thereby affecting Everglade's profitability.

Therefore, the causes of these losses, as well as their impact, need to be explored in order to mitigate the problem and develop strategies to reduce losses during these stages. This case study will examine the extent of FL at each stage of the FSC, identify the underlying causes, and propose effective strategies to address the issue.

1.3. RESEARCH OBJECTIVES

The general objective of the study is to assess granadilla loss and waste at each stage of the SC. The specific objectives include:

i. To evaluate key stages in the granadilla SC where FL occur.
ii. To evaluate the primary causes of this FL

iii. To evaluate the impact the FL has on the business, by quantifying of the levels of FL.
iv. To evaluate the strategies that are currently being used to reduce FL on the farm.

1.4. RESEARCH QUESTIONS OR HYPOTHESIS

To attain these objectives, the following research questions will be addressed:

i. What are the key stages in the Everglades granadilla SC where FL occurs?
ii. What are the main causes of FL?
iii. What impact does FL have on the profitability of the business, and can this impact be quantified through measuring FL?
iv. What strategies are presently being used to reduce FL on the farm?

1.5. THE SCOPE OF THE STUDY

This study focuses on analysing FL within Everglades Farm's granadilla SC. The stages of the FSC that will be examined include production/agriculture, post-harvest, and processing and a part of distribution. For exports, the research will conclude once the fruit is received at the airport. The analysis will cover the granadilla SC for the past three to four granadilla seasons to see any patterns or trends.

The research will involve SC stakeholders such as farmers, managers and transporters. Their perspectives will be gathered through interviews and observations.

The study will not cover granadilla production or consumption outside Mkushi, nor examine highly technical aspects of agricultural production such as soil analysis or pest examination, unless they directly impact FL. Additionally, the study will not include FW at the consumption stage of the SC. The focus will be on losses that occur before the product reaches the customer.

This research will focus specifically on the purple granadilla (Passiflora edulis forma edulis).

1.6. THE SIGNIFICANCE OF THE STUDY

As has been mentioned, the FL Everglades Farm encounters, pose significant challenges. These challenges affect the farm's profitability and operational efficiency, therefore making it crucial to understand and tackle these issues comprehensively.

Presently, there is limited data on the level of FL and specific causes of FL within Everglades Farm thereby creating a knowledge gap in effective food management across the SC. While several studies have explored FL and FW in various agricultural supply chains, there is limited research focused on the granadilla SC in Zambia and more specifically in Mkushi. Most existing literature examines the major global food crops such as maize or soya leaving the smaller yet economically significant crops such as granadillas understudied. By addressing this gap, this research aims to explore and provide key findings into granadilla waste prevention strategies along the different stages of the SC, in the local context, contributing to both food security and sustainability efforts for the company. Furthermore, these studies will serve as a valuable resource to other organisations within the industry, offering a model for sustainability practices, and contributing to broader efforts to reduce FW and promote sustainability.

1.7. THE ORGANIZATION OF THE REPORT

The remainder of this research paper is presented as follows: Chapter Two contains the literature review, followed by the empirical review and the theoretical framework surrounding FL in granadilla SC and related fruit supply chains in sub-Saharan Africa. This will be illustrated by the conceptual framework. Chapter Three will develop the research methodology, detailing the research design and methods of data collection and analysis. Chapter Four will present and analyze the results. In Chapter Five, the major findings will be discussed. Finally, Chapter Six will provide recommendations based on the study's findings and conclude the study.

This chapter explored the distinction between FL and FW, focusing on their economic impacts globally. It began by analyzing the key stages of the FSC and how FL occurs at each stage in various regions around the world. The chapter then narrowed in on a specific case, examining Everglades farm in Mkushi and the FL challenges it faces within its SC. The chapter outlined the objectives of the study, which aim to identify the causes of FL at the farm, assess its impact on the business, and quantify the amount of fruit lost at each stage of the SC.

II. CHAPTER 2: LITERATURE REVIEW

2.1. INTRODUCTION

This chapter reviews existing literature on FL and FW along the SC. It goes into depth about the existing qualitative and quantitative findings of key causes of FL at different stages of the SC, FL measuring methodologies, as well as current FL mitigation strategies. It also explored theoretical frameworks relevant to FL reduction including Collaborative SC Theory, System Theory, the Theory of Constraints and Resource-Based Theory, to provide a conceptual foundation for the study.

2.2 LITERATURE REVIEW

2.2.1 FOOD LOSS AND FOOD WASTE IN THE FRUIT SUPPLY CHAIN

FL and FW in the fruit SC is a global challenge, particularly for perishable crops like granadilla and other tropical fruits. The Food and Agriculture Organization of the United Nations (FAO) conducted a study showing that, in developed regions, fruit losses occur predominantly at the harvest stage; through the sorting grading and disposal of fruits and vegetables that do not meet the quality standards set by retailers (Rezaei & Liu, 2017). However, in developing countries, FL is also high at the harvest stage due to sorting and grading (Rezaei & Liu, 2017). Figure 2 shows the results of this study. The bar chart shows the percentage loss of fruits and vegetables at each stage of the FSC. “Agriculture” pertains to the losses that occurred during the harvest as well as the sorting and grading. “Post-harvest” pertains to the losses that occurred during the handling, storage and transportation after the harvest and before processing.

Focusing on Sub-Saharan Africa, Figure 2 shows that in countries in sub-Saharan Africa such as Zambia approximately 10% of FL happens at the agricultural stage of FSC, 8% of FL happens at the post-harvest stage of the FSC, 20% of FL happens at the processing stage of the FSC, 10% of FW happens at the distribution stage and 14% of food waste happens at the consumption stage of the FSC.

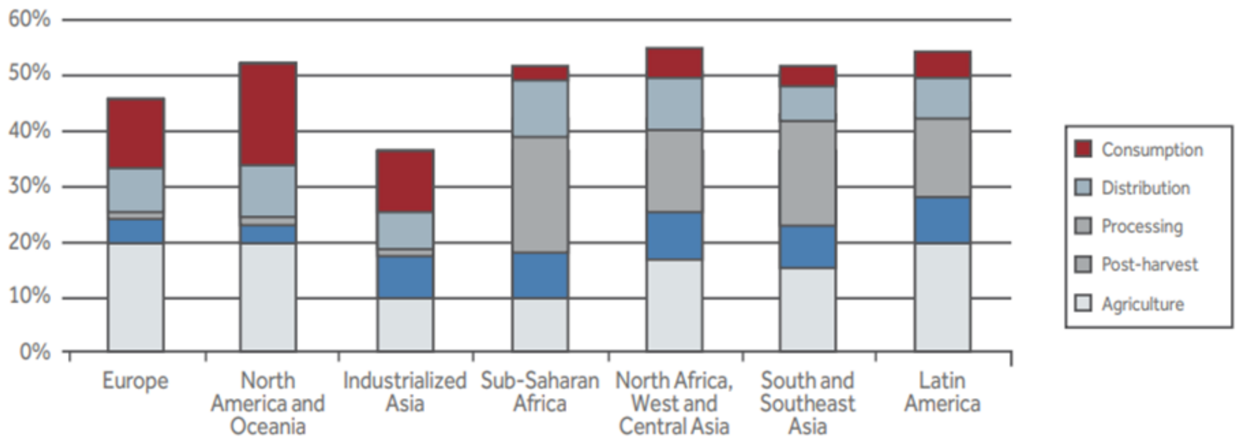

Figure 2: Percentage of FL and FW at different stages of the supply chain, in different regions (Rezaei & Liu, 2017).

Despite extensive research on FL, gaps remain in understanding granadilla SC losses, particularly in sub-Saharan Africa. These include examples such as the contextual research gap. Existing studies focus on staple crops and widely traded fruits, with limited research on the granadilla. There is little data on causes of FL across the granadilla SC. This study provides context-specific insights into granadilla FL in Zambia. Given the knowledge gaps in the granadilla SC regarding FL, it is noteworthy that fruits like mangoes and papayas, which share similar perishability characteristics, experience an annual waste rate of 40% despite strong demand in local, regional, and international markets (Comesa Regional Investment Agency, no date), with most losses occurring at the post-harvest stage of the SC.

2.2.2. UNDERSTANDING FOOD LOSS: A COMPARATIVE ANALYSIS OF QUANTITATIVE AND QUALITATIVE APPROACHES

As has been mentioned FL remains a significant challenge in sub-Saharan Africa, impacting food security and economic stability. Understanding its root causes is essential for developing effective interventions. Researchers have employed both quantitative methods and qualitative methods such as approaches to investigate these causes. This section compares findings from both methodologies to provide a comprehensive understanding of the factors contributing to FL.

2.2.2.1 Key Findings from Quantitative Studies on Food Loss in the Supply Chain

Quantitative research provides measurable, objective data on FL across the SC. By applying statistical and standardized methods. Such studies illuminate patterns, causes and magnitudes of FL at various stages. Techniques such as regression analysis, modelling and frameworks like the United Nations Economic Commission for Europe (UNECE) FL measuring methodology are commonly used. These approaches focus on calculating the percentages or volumes of FL by weight, value or energy content, identifying correlations between FL and key variables such as infrastructure, climate and transportation and evaluate the impact of interventions through predictive modelling.

i. Infrastructure and Food Loss

Studies undertaken using quantitative analysis showed that poor road infrastructure and lack of storage facilities are among the leading contributors to post-harvest losses. For example, a study in Kenya conducted by Affognon et al., (2015) showed that inadequate rural roads lead to a 30% higher spoilage rate for perishable goods. Lack of good transportation systems in sub-Saharan countries can lead to mechanical, physiological, and microbial damage, which lowers the quality of the granadillas (Bancal and Ray, 2022). Additionally, poor roads, breakdowns, lack of proper vehicles such as refrigerated vehicles, and delays in time between harvest and distribution can be challenges to fruits like granadillas, as they have a short shelf life and require immediate processing and cooling (Bancal and Ray, 2022).

ii. Crop Specific Food Loss

Additionally, a regression analysis undertaken by Parfit et al., (2010), showed that sub-Saharan crops such as maize, tomatoes and bananas revealed that losses during production and distribution are driven by pest infestations and poor harvesting techniques. The perishability of fruits, combined with recurring diseases, pests, and contamination, has been recognized as the primary cause of fruit wastage (Bartezzaghi et al, 2022). At the production level, FL in cultivation and harvesting can be linked to natural trends that reduce the quality and quantity of the fruit such as variability in weather, extreme weather, disease, pests and contamination (Bartezzaghi et al, 2022). Fungal infestation is a major threat to the commercial production of passion fruit (Nor et al, 2022). These diseases include infestations such as “Phytophthora cinnanomi, Phytophthora nicotinae, and Colletotrichum gloeosporioides” (Nor et al, 2022), which can cause collar rot, crown rot and fusarium wilt in passion fruit. Therefore, strategies need to be put in place in order to control pests and diseases that pose a threat to the plant. Additionally, Inefficient harvesting techniques can often lead to physical damage to the fruit, making it more susceptible to rot. These inefficiencies can result from a lack of proper harvesting materials and tools, rough handling during the harvesting process, and inadequate shade or designated storage spaces for the fruit (Bancal and Ray, 2022). According to Joy and Divya (2016), granadillas should be kept as cool as possible to minimize moisture and slow down undesirable chemical changes. The principles of post-harvest handling for granadillas include: handling the product with care, cooling the fruit immediately by providing shade, and removing any damaged products through careful sorting methods (Joy and Divya, 2016).

iii. UNECE Methodology

The UNECE FL measuring methodology derived from UNECE (2020), quantifies losses at each stage of the SC, highlighting the processing stage as the most loss-prone stage for fruits and vegetables in sub-Saharan Africa.

These quantitative methods deliver clear numerical estimates that enable comparisons. These findings can be generalised across regions. However, they can lack the ability to capture context-specific nuances, such as the cultural or institutional factors influencing FL and therefore, this is where qualitative analysis comes in.

2.2.2.2 Insights from Qualitative Studies on Food Loss in the Supply Chain

Qualitative research delves deeper into the causes and context of FL, providing nuanced findings into behaviours, practices and systematic challenges of stakeholders in the SC. Unlike quantitative analysis, qualitative analysis will explore the reason behind FL through interviews and observations, while discovering behavioural and institutional barriers such as market dynamics, and policy gaps, and documenting the lived experiences of SC actors to provide practical insights. These include:

i. Farmer Behaviour and Loss

A study conducted in Nigeria, through the use of interviews with small-scale farmers, revealed that limited knowledge of post-harvest practices and management and dependence on traditional storage methods are major contributors to FL (Kikulwe et al., 2020). Fresh products are vulnerable to physiological damage, including sunburn, dehydration, and internal breakdown when stored at incorrect temperatures at any stage along the FSC (Bancal and Ray, 2022). Limited access to cold storage in rural areas can lead to accelerated deterioration, especially during the hot season. Without proper storage, granadillas may begin to deteriorate before reaching the market, resulting in significant losses. According to Paull and Chen (2014), yellow granadillas should be stored at temperatures between 7 to 10°C with 90 to 95% relative humidity, allowing for a longer potential storage life of approximately two weeks. In contrast, purple granadillas can be stored at 3 to 5°C and have a longer storage life of three to five weeks. Proper storage not only extends shelf life but also protects the fruits from insect and rodent attacks, further decreasing losses.

ii. Policy and Infrastructure

Qualitative studies in East Africa highlight that complex export requirements and lack of cold chain infrastructure are primary barriers to reducing food loss (Gustavssin et al., 2011). Product exclusion is a significant factor in FL, influenced by various aspects of the fruit, such as improper weight and size, discolouration, and damage. For export-grade granadillas, specific standards must be met. An example of these standards is shown in figure 3 below.

Maturity indices of passion fruit in global trading (Codex Alimentarius, 2014)

Indices	Descriptions
Size (Diameter)	Small (5 cm) Medium (6.5 cm) Large (8 cm)
Peel colour	Green—not ripen 50% purple colour—acceptable for market 75% purple colour—acceptable for market 100% purple colour—highly desirable
Soluble solids concentration	13–18 °Brix

Figure 3: Global Trading specifications for Granadilla Fruit (Nor et al, 2022)

In sub-Saharan African countries, this could result in the exclusion of nearly 40% of the fruit produced, as studies indicate that 40% of the fruit is wasted before it even reaches the distribution stage. This can also be detrimental for a farm if it overproduces granadillas in hopes of exporting the fruit, only to have the majority rejected for not meeting international standards. This can lead to an excess of fruit that may go to waste due to lower local consumption.

In addition to fruit quality conformance, another aspect that can affect the fruit quality is the packaging. In sub-Saharan Africa, fruits are often poorly packed in wooden crates or overloaded and reused cardboard boxes (Bancal and Ray, 2022). This improper packaging can lead to compression bruising, as granadillas are piled on top of each other, which can split or deform the fruit. This damage reduces the number of granadillas that can be sold in both domestic and export markets. Passion fruits require well-ventilated containers that can be stacked without causing damage (Joy and Divya, 2016). For the domestic market, packaging for granadillas can be more flexible, utilizing wooden or plastic crates. However, for the export market, the preferred packaging is single-layer fibreboard cartons, typically containing either 2 or 3.5 kg of fruit, with ventilation. The inaccessibility of these types of packaging in Zambia can create challenges for Zambian granadilla producers in exporting their products, as they may not meet international packaging standards.

As can be seen, both quantitative and qualitative studies have concluded on certain outcomes of FL along the SC. The Quantitative approach gave objective data, meanwhile the qualitative method offered contextual insights into systematic and behavioural drivers of FL. Combining both effectively address FL challenges. Further causes of FL will be addressed according to various studies conducted.

2.2.3 Additional Causes of Food Loss Along the Granadilla Supply Chain

There are additional primary factors have been studied that contribute to FL in the granadilla SC, these align with broader trends seen in other tropical fruits.

2.2.3.1. Lack of Processing Capacity

The lack of processing capacity is a way in which food can be lost along the SC, particularly at the distribution and retail stages. This is the case in several developing countries. Modern equipment is lacking; therefore, most fruits are sold in their fresh form (Bancal and Ray, 2022). This leaves a significant amount of fruit that could be processed into juices, jams, or other value-added products, potentially leading to waste.

2.2.3.2. Lack of Coordination and Information Sharing among Stakeholders in the Food Supply Chain

Lack of coordination and information sharing can be contributing factors to FL and waste. Studies show that the closer the relationship between stakeholders in the food supply chain, the lower the levels of FL and waste (Bancal and Ray, 2022). For instance, inaccurate demand estimation may affect losses in retail markets. An overestimation can cause farmers to plant and harvest more than the market and consumer needs, leading to excess fruit going to waste. Additionally, the FSC is different and somewhat more challenging and sensitive to handle than other supply chains due to factors like food quality and safety within restrictive time constraints (Jamal, 2014). Given the limited time frame and sensitivity with which fruits must move from one stage of the SC to another, relevant parties within the FSC need to cooperate effectively and maintain frequent communication to ensure that fruit quality is not compromised and, therefore, wasted.

2.2.3.3. Weather Variabilities and Climate Change

Climate change and weather variability can be significant factors in crop losses (Bancal and Ray, 2022). Fruit may suffer damage due to extreme weather, leading to rejection during the sorting process or a reduction in crop yields. According to Sirba and Chimdessa (2022), due to crop failures caused by climate change-driven events, African farmers are losing approximately “US$28 per hectare per year for each 1°C rise in global temperature.” Additionally, climate change can increase pest occurrence, which then leads to yield loss (Sirba and Chimdessa, 2022). As the climate becomes warmer, the range of agricultural pests expands, resulting in greater attacks on crops. Climate change can also affect precipitation patterns, which can either lead to droughts or floods. Granadillas need consistent moisture, so either extreme can negatively affect growth and yield. To mitigate this issue, some farmers overproduce, but this oftentimes just leads to unnecessary oversupply and waste.

2.2.4. ECONOMIC AND ENVIRONMENTAL IMPACT OF FOOD LOSS

FL along the SC can significantly affect the economic sustainability of the farmers and traders. This section will assess the economic consequences of FL at the different stages of the SC, focusing on production, post-harvest, handling and distribution.

2.2.4.1. Financial Loss for Farmers

In the production stage, as has been mentioned, granadilla farmers can face losses due to pests, diseases and poor harvesting techniques. As shown in Figure 2, countries in sub-Saharan Africa experience approximately 38% of FL before it reaches the market. This translates into a direct reduction in income for the farmers. Thus, for example, assuming a farmer harvests 1,000 kilograms (kg) of granadillas per season, and the market price is K30 per kg, a 38% loss results in a 380kg loss of granadillas or K11,400 in potential income that is never realised. Additionally, this loss can increase the financial strain on small-scale farmers who rely on fruit sales. Without proper SC practices such as proper storage and post-handling practices, they may be forced to sell their produce at lower prices or let it go to waste further diminishing their potential earnings.

2.2.4.2. Impact on Traders and Distributors

Traders and distributors in the granadilla SC also incur financial losses due to spoilage during the transportation and storage stages of the SC. Poor infrastructure such as inadequate road networks and limited cold chain facilities, exacerbates these losses. According to Wang, Liu and Ahmad (2024), cold chain logistics costs are considerably higher than ordinary logistics, with logistics and transportation costs constituting a significant portion of the overall costs, as it requires complex management and continuous low-temperature maintenance. Thus, every fruit sale counts in order to make their businesses profitable. If 10% of the fruits are lost at the distribution stage of the SC, as seen in Figure 2, these losses reduce potential revenue and increase the operational costs for traders and distributors, thereby limiting opportunities for economic growth. As a result, traders and distributors may be forced to make the decision of either increasing prices for consumers or reducing their profit margin.

2.2.4.3. Broader Economic Impact

On a national scale, FL in the granadilla supply chain can reduce the agricultural sector's contribution to Zambia's Gross Domestic Product (GDP). Agriculture contributes close to 10% of the country's GDP (FAO, n.d.), with horticulture, including fruit farming, being a growing component. Additionally, according to the United Nations COMTRADE database on international trade, Zambia's exports of edible fruits, nuts, and tropical fruits, were approximately US$3.39 million in 2023 (Trading Economics, 2024). This indicates that there is potential for the agricultural sector to grow. However, significant losses in high-value crops like granadillas can weaken this sector's overall performance. Furthermore, FL reduces the potential for export growth, limiting Zambia's ability to tap into international markets where granadilla may fetch higher prices. As mentioned before, there is international demand for granadillas, particularly in the United Kingdom (UK), where granadilla imports were valued at approximately $116.8 million in 2023 (Tridge, 2024). Thus, Zambian farmers have the potential to access this market. However, since 14% of food is lost at the distribution stage, as shown in Figure 2, the country loses potential export revenue. For instance, if Zambia were to export 50,000 kg of granadillas but 14% is lost during production, the country would lose the potential export revenue from 7,000 kg of granadillas. If the export price was K50 per kilogram, this equates to a loss of K350,000 in revenue that could have contributed to the national economy.

2.2.5. POTENTIAL STRATEGIES FOR REDUCING LOSSES

Several interventions have been studied that could mitigate FL in the granadilla SC. These interventions can address the various causes of FL and waste.

2.2.5.1. Increased Control of Pests and Diseases

Increasing control of pests and diseases can help reduce FL along the SC. As mentioned earlier, granadillas are susceptible to pests and fungal diseases. One example of this is in Malaysia. A study conducted by Nor et al. noted that in 1960, a granadilla project was cultivated on a commercial scale there; however, due to a fungal disease outbreak, the project was unsuccessful. Nevertheless, through research into fungal control, the granadilla industry saw significant progress. Studies found that the use of relevant chemicals and bio-fungicides was effective in controlling bacterial and fungal diseases in the plant. The progress made in fungal control and pest management is a testament to the importance of ongoing research and the development of sustainable agricultural practices. With the right combination of pest management strategies, such as the use of chemical treatments and environmentally friendly bio-fungicides, the granadilla industry has been able to increase its production and reduce losses along the supply chain.

Furthermore, additional studies have been conducted, and comprehensive manuals have been developed by organizations such as USAID (2019) to address the prevention and management of various diseases and pests that affect granadilla production. These resources provide valuable guidance on effective strategies for tackling the challenges faced by granadilla farmers, particularly in regions where pest and disease pressure is high. Following the protocols outlined in these manuals could serve as an effective method of pest control and disease reduction thereby reducing FL caused by disease and pests.

2.2.5.2 Improve Cold Storage Management

Cold storage is essential for perishable products like granadilla, as it delays the ripening process and prevents spoilage. However, in many parts of sub-Saharan Africa, there is a lack of access to cold storage facilities due to high costs and unreliable electricity. The introduction of decentralized cold storage solutions, such as solar-powered cold rooms would allow farmers to store their fruits in optimal conditions after harvest. These cold rooms can delay the ripening process and reduce the levels of spoilage, especially in Zambia's warm climates. According to Asadi and Hosseini (2014), the success of the food industry has continued to rely on the cold chain being handled effectively. By definition cold chain management is "the process of planning, implementing and controlling the flow and storage of perishable goods, related services and information to enhance customer value to ensure low costs" (Shashi et al 2021, p. 102). A food chain is a complex system with many static and moving elements as can be seen in Figure 4 below. It requires accountability from different levels of the SC such as farmers, processors, aggregators, manufacturers, retailers and distributors as well as consumers (FAO, 2022). The food cold chain Stages typically include primary processing such as sorting and grading, packaging, precooling, refrigerated warehouses, and cold storage at the wholesale and retail level, with the integration of refrigerated carriage on moving components such as trucks and aircrafts (FAO, 2022). Temperature management is critical during the transportation of fruits, particularly over long distances such as distances covering Zambian markets or exports to other countries. Thus, to enhance the quality and longevity of their fruits, farmers could seek to invest in cold chain management systems. By doing so, they can ensure that their fruits remain in optimal condition from the moment of harvest through storage, transportation, and delivery to consumers as well as significantly reduce levels of FL along the supply chain, helping to minimize waste and maximize profitability.

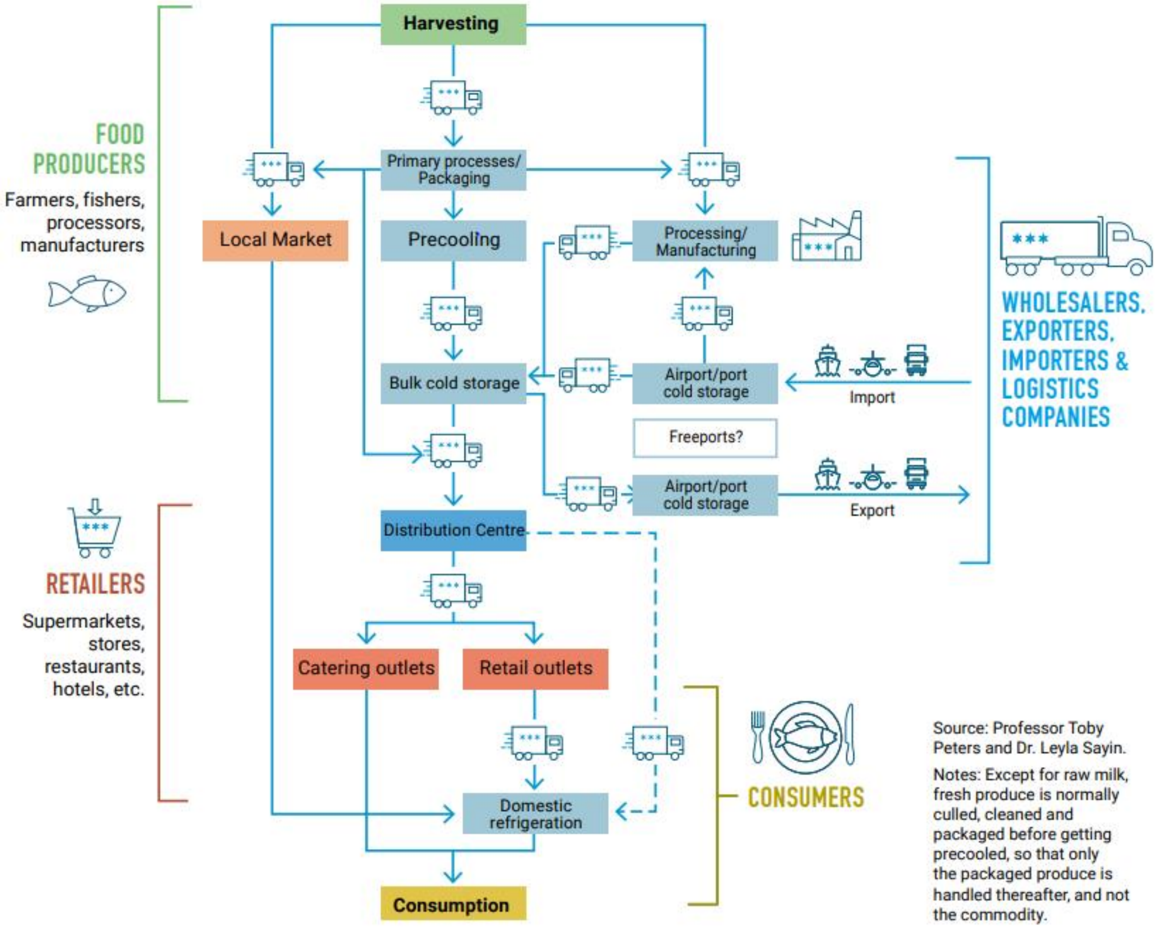

Figure 4: Typical food logistics cold chain steps and stakeholders (FAO, 2022)

2.2.5.3 Training and Capacity Building for Farmers

Training programs focusing on improved harvest and post-harvest handling practices are essential for minimizing losses at the production levels. Farmers can be trained on proper picking techniques to prevent physical damage to granadilla fruits, proper handling during the sorting and grading level and proper packaging methods in order to preserve the quality of the produce. These training efforts would help farmers adopt practices that reduce losses due to improper harvesting timing, especially when the fruits are picked at the wrong maturity stage, as well as reduce losses due to bruising and rough handling. An example of a post-harvest technique taken from (Joy and Divya, 2016) is that the fruit needs to be harvested with care, and placed in a plastic bucket or field container lined with newspaper and padding, without dropping or throwing the fruit in order to minimise bruising and scarring (Joy and Divya, 2016). Such simple steps could significantly reduce FL.

2.2.5.4 Use of Appropriate Packaging

As mentioned in section 2.1.2.4, effective packaging solutions play a crucial role in maintaining the quality of fruits during transportation. Optimal practices include using well-ventilated containers, wooden or plastic crates for the domestic market, and single-layer fibreboard cartons for the international market. These packaging methods are designed to ensure proper airflow and protection, significantly reducing the risk of damage. In contrast, more traditional packaging methods, such as sacks or baskets, can often lead to bruising or crushing during transit. These methods, while familiar, may not provide the necessary support and protection that modern practices offer. Therefore, it is essential to utilize appropriate breathable packaging for long-distance distribution to preserve fruit quality and freshness. Additionally, suitable protective packaging is necessary to prevent crushing. This dual approach not only safeguards the fruits from physical damage but also ensures that they arrive at their destination in optimal condition, thereby enhancing customer satisfaction and reducing food waste. By investing in these best practices, producers can improve the overall efficiency of their supply chains and better meet market demands.

2.2.5.5 Market Diversification and Value Addition

One of the most effective ways to reduce FL is through market diversification and value addition. Value addition is changing the fruit into a different form in order to increase the shelf life of the fruit (Divya and Joy, 2016). Because of their flavour, granadillas can be made into jams, fruit juices, ice cream and liquor (Divya and Joy, 2016). By diversifying their product offerings, farmers can tap into different markets and attract a wider customer base. This not only helps mitigate the risk associated with relying solely on fresh fruit sales but also introduces consumers to innovative and value-added products. This can be particularly used for unsold granadillas, or fresh granadilla fruits that do not meet market standards. However, it’s important to note that engaging in value addition can be costly. The initial investment in processing facilities and equipment can be significant. Farmers may need to weigh the benefits of diversification against these costs. For instance, a commercial juicer bought online can cost up to $20,000 (Made in China, 2024). Additionally, they may require training and support to develop new skills in food processing and marketing. Despite these challenges, the long-term benefits of market diversification and value addition can lead to improved profitability and reduced FL. For instance, granadilla fresh fruits may cost K20 per kg, while a Granadilla jam can be priced at K80 per bottle, more than double the price of fresh fruit granadillas. By embracing this strategy, farmers can reduce waste in the FSC and provide alternative uses for fruit that might otherwise go unsold.

2.2.5.6 Supply Chain Collaboration

Supply chain collaboration plays an important role in reducing FL by fostering coordination and communication among various stakeholders, including farmers, distributors, and retailers. In the context of supply chain management, collaboration refers to the effort to achieve business objectives and goals through cooperative communication and teamwork (Council of Supply Chain Management Professionals, 2013). This collaborative approach is essential, as it enables stakeholders to align their interests and resources, creating a more efficient and responsive SC. As mentioned previously, the closer the relationship between stakeholders in the food supply chain, the lower the levels of FL and FW (Bancal and Ray, 2022). Strong partnerships allow for better sharing of information regarding inventory levels, demand forecasts, and shelf life, leading to more informed decision-making. Moreover, improved communication between stakeholders facilitates SC integration, allowing for a seamless flow of products from the farm to the customer. When stakeholders actively engage in dialogue and share data, they can identify potential bottlenecks and inefficiencies within the SC that often cause fruit spoilage. Collaborative efforts also promote innovation, enabling stakeholders to develop and adopt new technologies and practices that further minimize FL. For instance, information sharing with for instance clearing agents at the airport, as well as government agencies that supply relevant export certification, can help assist in the seamless flow of the fruits from the farm to the airport and aboard the plane, mitigating delays that contribute to spoilage. Additionally, collaboration can help in creating standardized practices across the SC, which can enhance quality control and consistency in the fruits. By working together, stakeholders can implement best practices for handling, storage, and transportation, ultimately leading to a reduction in waste. As farmers face increasing pressure to operate sustainably, SC collaboration will be essential in creating resilient systems that contribute to a reduction in FL.

2.2.6. Understanding Food Loss: A Comparative Analysis of Quantitative and Qualitative Approaches

As has been mentioned FL remains a significant challenge in sub-Saharan Africa, impacting food security and economic stability. Understanding its root causes is essential for developing effective interventions. Researchers have employed both quantitative methods and qualitative methods such as approaches to investigate these causes. This section compares findings from both methodologies to provide a comprehensive understanding of the factors contributing to FL as well as additional causes of FL and additional strategies to mitigate it.

2.3 THEORETICAL FRAMEWORK

In order to address the issue of FL within the granadilla SC at Everglades farm, this research will seek to employ a number of theoretical frameworks in order to provide an understanding of the underlying factors and dynamics at play. These theories will serve as a lens through which issues will be examined and enable stakeholders to identify challenges and effective strategies for prevention. The selected theories include; Collaboration Supply chain Theory, Systems Theory, Theory of Constraints, and Resource-based theory.

By integrating these theories, this study aims to provide an understanding of the dynamics affecting FL in the granadilla supply chain and propose actionable strategies for improvement

2.3.1 Collaboration Supply Chain Theory

Collaboration is a process whereby collaborative stakeholders within a SC work together toward a common goal that mutually benefits the stakeholders (Min et al, 2005). In a collaborative SC, stakeholders such as producers, distributors and retailers, work closely, share information, align objectives and jointly solve problems. A collaborative SC theory emphasizes the importance of cooperation and interdependence among SC actors to enhance efficiency, reduce costs and improve outcomes. SC collaboration is essential to the business environment of an organisation, especially in the food industry where perishability and demand variability exist (Dania et al., 2016). Research shows that SC collaboration leads to several benefits such as improved quality of a product, reduction in costs, improved risk management, improved demand planning and increased economies of scale in production (Gumboh and Gichira, 2015).

In the case of the granadilla SC on the Mkushi farm, collaboration among producers, transporters and retailers can be beneficial. By sharing information on harvest schedules, transportation timing and demand forecasts, each stakeholder along the SC can better prepare for fluctuations in supply and demand or distribution schedules. For example, if the farmers inform distributors of expected harvest volumes and timing, distributors can plan their logistics to reduce delays in moving the perishable granadillas. One of the main drivers for collaboration that facilitates SC collaboration is information technology (Gumboh and Gichira, 2015). This has made it possible for chain partners to share information on different markets, as well as demand and supply and other relevant information in real-time. Three components of SC collaboration will be explored, that facilitate SC management as well as implement the use of technology. These are; Information sharing, joint problem solving and aligned objectives.

i. Information Sharing

Information sharing is the foundation of a collaborative SC. Information sharing is "The willingness to make strategic and tactical data available to other members of the supply chain" (Banomyong, 2018). The information-sharing process is necessary for routine operations but also vital for strategic and tactical decisions between SC partners (Banomyong, 2018). According to Min et al. (2005). Realistic, detailed and information sharing adds to improved SC efficiency and improved decision-making. In the granadilla SC, this can look like sharing data on production cycles, expected yields and market conditions could help SC parties to align their activities ultimately reducing FL. Information sharing can be done in real-time through the use of different technologies in order to ensure that the data is up to date, thereby reducing any delays.

ii. Decision Synchronisation

Decision synchronisation is "joint decision-making in planning and operational contexts" (Banomyong, 2018). The main purpose of this planning is to utilise the capacity and resources of SC partners. It can help to prioritize the objectives of the SC members. For instance, in the case of the granadilla SC, all SC partners can partner together to address shared challenges such as limited storage facilities or inadequate transport infrastructure discover solutions and make decisions and adjustments to the problems. Additionally, SC actors can address bottlenecks such as poor storage or operational delays and consider working together through the utilization of their resources to mitigate the issue.

iii. Aligned Objectives

Collaborative SC require SC stakeholders to align their objectives. This would be important particularly around reducing FL and improving SC sustainability. According to Ming (2005), creating internal and external SC alignments can yield benefits by helping to streamline operations such as information systems, logistics, and production cycles. Thus, in the case of the granadilla case, aligning objectives, particularly around reducing FL and improving SC sustainability would mean that each SC actor from producers to distributors understands the collective impact of FL on profitability and sustainability, which will then encourage cooperative efforts to prioritize waste reduction at each stage of the chain.

2.3.2 SYSTEMS THEORY

Systems theory is an “interdisciplinary framework that studies the relationships, interactions and interdependencies within a complex system” (Tenin, 2023). In other words, it views a system as a set of interconnected components working together to achieve a common goal. In the case of a food SC, it can be looked at as an interconnected network where each component from production to distribution functions as part of a larger system and is interdependent thus indicating that changes or inefficiencies in one part of the system can affect the whole SC. Thus, viewing the granadilla SC as interdependent, the actions of producers in the granadilla SC—such as their harvesting practices—directly impact the efficiency of downstream stages like storage and transportation. For instance, FL at the harvest stage may stem from poor handling practices. When these issues are not addressed, they cause a domino effect which can impact subsequent stages and lead to cumulative losses. In the context of FL, systems theory allows us to analyze the granadilla SC as an integrated system where each stage, production, processing, storage, transportation, and distribution, impacts the overall outcome. By addressing FL through a systems approach, the root cause of inefficiency can be identified, helping different parties within the SC to adopt practices that prevent FL at multiple stages simultaneously. Addressing FL, therefore, requires understanding these interdependencies and ensuring that each stage complements the others to reduce waste. This therefore makes it essential to address each stage of the SC as part of a cohesive whole.

Feedback loops are essential in a systems-based approach, as they inform the system on how or what to change to maintain balance (Heil, n.d.). In the case of a granadilla SC system feedback from distributors about spoilage rates can help producers and transporters adjust practices to improve handling, scheduling and storage. Thus, this can help provide an informed SC and a culture of continued improvement across the whole SC.

In summary, systems theory provides a valuable perspective on the granadilla SC by encouraging a holistic, interconnected approach to reducing FL. By viewing each stage of the SC as part of a larger system, stakeholders can better identify root causes and implement comprehensive solutions that reduce FL at multiple points in the chain. In the context of the granadilla farms, adopting a systems-based approach could help optimize resource use and improve the resilience and sustainability of the granadilla supply chain.

2.3.3 Theory of Constraints

The theory of constraints (TOC) is a theory developed by Eliyahu Goldratt. This theory focuses on identifying the most limiting factor in a process and improving it to enhance the overall performance (Theory of Constraints Institute, 2021). It identifies and addresses bottlenecks or constraints that limit the performance of a system. In the context of FL, TOC can be used to identify and address key bottlenecks that lead to granadilla waste in the SC. For instance, inadequate storage facilities, inefficient transportation and delays in processing can serve as constraints that reduce the freshness and quality of the granadilla, leading to significant losses. Thus, identifying and managing these constraints can minimize loss at various stages. For example, if transportation delays are identified as the primary constraint, then optimizing logistics through better scheduling or increased capacity can help alleviate the issue, resulting in reduced spoilage and waste.

There are five key steps in TOC. These steps have been sourced from Rahman (2002). The key steps of the TOC include:

i. Identifying the constraint – This step pinpoints the primary bottleneck or constraint within the SC. In the case of the granadilla SC, potential constraints might include limited cold storage at the production stage or inadequate transport during distribution. By identifying the constraint, SC stakeholders can focus resources on the area most in need of improvement.
ii. Exploiting the Constraint – In this step, once the constraint is identified, TOC suggests finding ways to make the most of the existing resources within that constraint. For instance, if limited cold storage is the main constraint, producers might look at strategies to reduce the harvest volumes to manageable levels, to ensure that the available storage facilities are used efficiently.
iii. Subordinating other processes – In this step TOC recommends adjusting the other stages of the SC to support the constraint. For example, if transportation is the bottleneck, upstream actors (like harvesters and packers) could time their processes to align with available transportation slots, ensuring that produce is not left to spoil while awaiting transport.
iv. Elevating the constraint – In this step long-term improvements are made to reduce the impact the constraint. For instance, in the granadilla SC elevating the transportation constraint could involve investing in more reliable refrigerated vehicles to reduce delays and losses.
v. Repeating the process – When one constraint is resolved, another can emerge. Therefore, continuously identifying and addressing the bottleneck can help optimize the entire system and prevent FL from occurring at different stages.

Thus, the TOC offers a practical framework for identifying and addressing the critical bottlenecks that contribute to FL in the granadilla SC. By focusing on specific, high-impact constraints, SC actors in Mkushi can implement targeted improvements that reduce FL, enhance overall efficiency, and support sustainable practices.

2.3.4 Resource-Based Theory

Resource-based theory (RBT) is a theory that suggest that an organisation's competitive advantage lies in its unique resources and capabilities (Hitt et. al, 2016). This could mean leveraging specific resources such as technology, skills infrastructure or partnerships to create value and efficiency. This theory aims to analyse a company's competitive advantage both internally and across the SC (Hitt et. al, 2016). In the granadilla SC, applying RBT may mean identifying unique resources each party brings to the SC and leveraging them to reduce FL. For instance, producers with specialized knowledge of harvesting techniques or access to specific preservation technology may reduce losses at the production and post-harvest stages. Additionally, distributors with well-maintained transport fleets may minimize spoilage during distribution. By strategically using resources that each actor possess – such as local knowledge, infrastructure or collaborative networks, stakeholders can collectively improve efficiency and reduce waste. One of the resources of RBT are valuable resources (Hitt et. al, 2016). Valuable resources are resources that help improve the efficiency or effectiveness of the SC. For instance, cold storage facilities or transportation equipment could be highly valuable in the granadilla SC as they preserve the fruit's freshness, reducing spoilage. Additionally, there imitable resources (Hitt et. al, 2016). These resources are hard to imitate, such as specialized skills in harvesting or handling granadillas, that create unique advantages. By further developing these unique skills, actors in the SC can improve the quality of fruits and reduce food losses in ways that are not easily replicated.

To summarize RBT highlights the importance of unique resources and capabilities in reducing FL in the granadilla SC. By identifying and strategically using valuable or inimitable resources SC parties in the farm's SC can create efficiencies that minimize loss and add value. RBT provides a framework for leveraging existing strengths and identifying potential areas for investment, contributing to the overall sustainability and resilience of the SC.

2.4. CONCEPTUAL FRAMEWORK

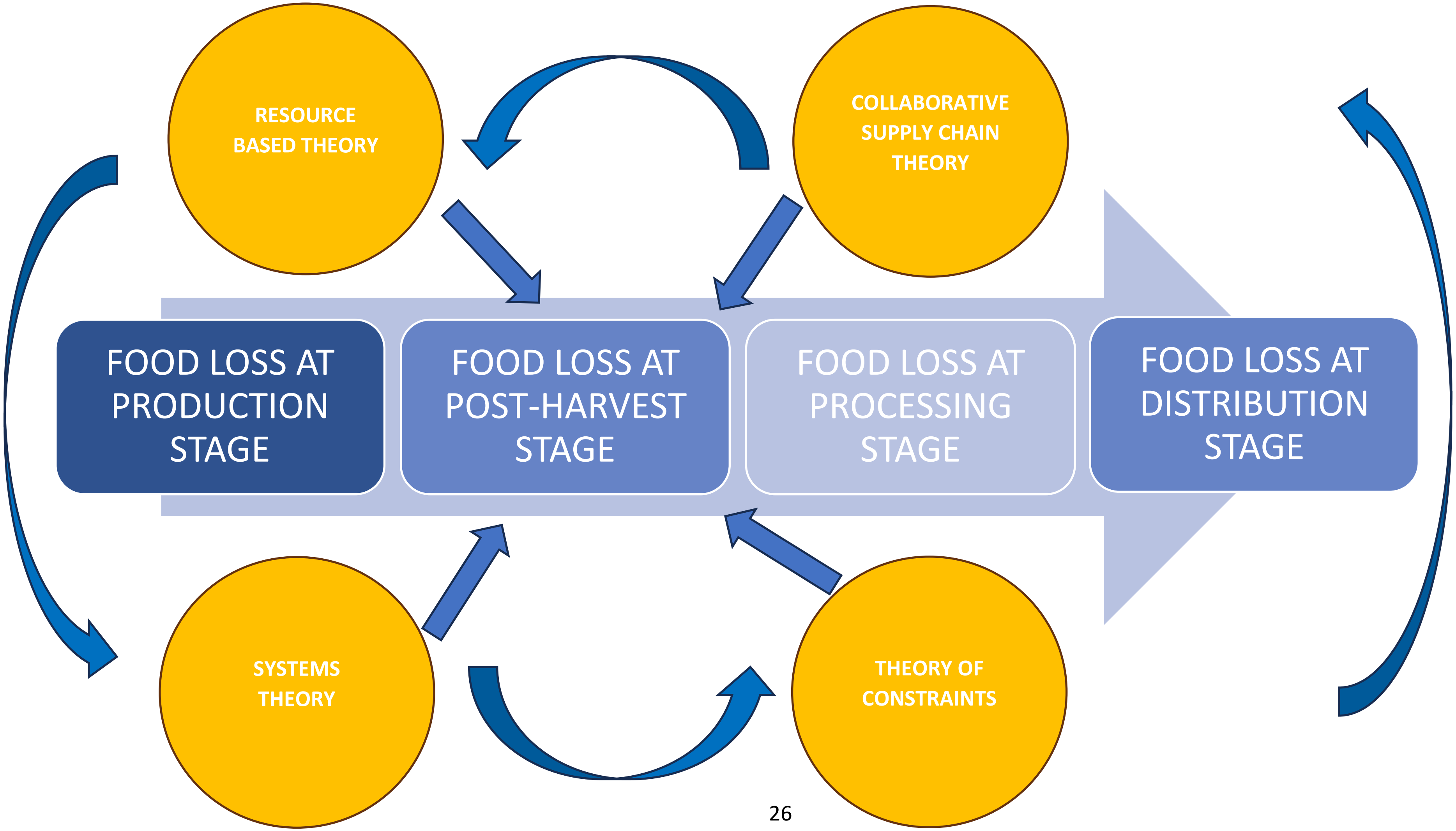

Figure 5: Conceptual Framework

2.5. SUMMARY

This chapter explored the literature on FL and FW within the SC. It identified key causes, including pests, contamination, poor storage, and inadequate temperature management. The chapter then examined potential strategies for reducing FL as the improvement of cold storage management and SC collaboration. Additionally, it discussed several theoretical frameworks—collaboration SC theory, systems theory, theory of constraints, and resource-based theory—and their relevance in analysing FL issues along the supply chain. These frameworks provide a foundation for understanding challenges and developing effective prevention strategies. Finally, a conceptual framework was created to visually represent the theoretical foundations of the study.

III. CHAPTER 3: METHODOLOGY

This Chapter outlines the research methodology that was used to investigate FL in the Granadilla SC in Everglades Farm. It provides an overview of the research approach and design, the study population, the sample size, the sampling design, data collection, data analysis, as well as the anticipated limitations and the ethical considerations.

3.2 RESEARCH APPROACH AND DESIGN

This study adopted a case study design to examine FL within the granadilla SC on a particular farm in Mkushi. A case study approach was particularly valuable for this research as it allowed for an in-depth exploration of a single SC. Given the complexity of SC interactions and the influence of factors such as export constraints, collaboration, and operational controls, a case study allowed for a detailed exploration of these dynamics in a real-world context. This approach was particularly valuable in sub-Saharan Africa, where granular data on FL is often limited, enabling the study to generate practical insights that could inform industry practices and policy interventions. By focusing on the granadilla SC on this farm, this approach facilitated a detailed analysis of the unique factors that contributed to FL at each stage, from production to distribution.

The case study used a concurrent triangulation design. Concurrent triangulation design is a mixed methods approach that involves collecting and analysing qualitative and quantitative data simultaneously to cross-validate the findings. This design was particularly suitable for examining FL in the granadilla SC, as it allowed for numerical assessment of FL at different stages and in-depth insights from stakeholders involved in the production, processing, and distribution. By integrating these methods, the study ensured a more comprehensive understanding of the factors contributing to FL, reducing potential biases that may arise from relying on a single data source. Additionally, given the limited availability of detailed granadilla FL data in Sub-Saharan Africa, concurrent triangulation strengthened the study's reliability by corroborating quantitative measurements and findings with qualitative perspectives from SC personnel.

Qualitative data were gathered through observations and interviews to understand the company's operations, including what activities were performed at each stage and the managers' assumptions about FL and FW at each stage of the SC. Quantitative data were collected by measuring FL at each point in the SC. By combining these data types, this offered a well-rounded perspective on the matter.

3.2. STUDY POPULATION

The study population consisted of employees working in the granadilla production and processing in Mkushi. A total of five employees were interviewed. The total workforce ranged from approximately 200 – 400 employees, varying due to seasonal labour demands. During peak seasons, additional workers are required for harvesting and processing, leading to fluctuations in workforce size. The population consisted of:

i. Farm workers – These are primarily responsible for planting, maintaining and harvesting granadillas. Their duties include pruning vines, monitoring plant health, applying fertilizers and pesticides and manually picking ripe fruit during the harvest season.
ii. Processing workers – These handle post-harvest activities such as sorting, grading, cleaning and packing granadillas for distribution. They ensure that only high-quality fruits are selected for export while managing rejected granadillas.
iii. Managers and Directors – These oversee the farm operations, ensuring efficient production and compliance with export regulations. They make strategic decisions on planting schedules, resource allocation, quality control and workforce management. Directors also engage in negotiations with buyers and regulatory bodies.
iv. Logistics personnel – These manage the transportation and distribution of the granadillas from the farm to the processing facilities and then to the final market. Their responsibilities include coordinating transportation, ensuring proper storage conditions before and during transit and assisting in proper loading and offloading of the granadillas.

By involving these stakeholders, the study aimed to capture insights into the challenges and efficiencies withing the granadilla SC.

3.3. SAMPLE SIZE

The sample size for this study consisted of five individuals who were directly involved in the operations of Everglade's granadilla SC. These individuals included the director of the farm, the export manager, the processing/pack shed manager, the production manager and the transporter. A sample size of five was considered sufficient for this study due to the qualitative nature of this study which focused on gathering in-depth insights from the key stakeholders with distinct roles in the granadilla SC.

The selected individuals provided diverse perspectives on the factors contributing to FL, reflecting the multi-faceted nature of the SC. The criteria for selecting these individuals were based on their direct involvement and expertise in specific stages of the SC. For instance, the director of the farm provided a high-level view of the farm operations, strategic decisions to improve the FL and challenges faced on the farm. The Export Manager offered insights into the complexities and constraints of the export process, particularly related to export regulations and procedures. The Production Manager focused on cultivation, and harvesting and provided more insights into where FL may occur and the causes. The processing/pack shed manager was involved in processing and packaging, an area where FL is directly influenced by sorting, grading and handling procedures. Lastly, the transporter played a key role in logistics and distribution, with a focus on the conditions that affect the granadillas during transportation which can contribute to FL.

By including these diverse roles, the study was able to capture a wide range of perspectives, ensuring that the factors influencing FL were explored from various points in the SC. This comprehensive approach allowed for a more holistic understanding of the challenges faced at each stage, thus justifying the adequacy of a sample size of five individuals.

3.4. SAMPLING DESIGN

The sampling technique that was used was the judgmental or purposive sampling method. It was chosen for this study because it aligns with the qualitative nature of the research and the specific objectives of the study. Purposive sampling allowed for a selection of individuals who had direct experience with the granadilla SC in Mkushi, which was critical to understanding the factors contributing to FL. By selecting individuals who were actively involved in the key stages of the SC, this method ensured the sample included the individuals whose roles and experiences were the most relevant to the research questions.

Some of the advantages of using purposive sampling for the research included – purposive sampling ensured the participants possessed specific knowledge, expertise, and experience related to the granadilla SC. This was crucial for obtaining in-depth, insightful data regarding the factors influencing FL, which may not have been possible with other sampling designs such as the random sample. Additionally, given the focused nature of the study as well as the time and resource constraints, purposive sampling minimized the need for a large sample size and allowed for a more manageable research process. Lastly, by selecting participants from different roles within the SC, the research captured a wide variety of perspectives. This enriched the understanding of FL across the different stages of the granadilla SC.

The participants were selected based on the following criteria:

i. **Direct involvement in the Granadilla SC:** The individuals needed to be actively engaged in various stages of the granadilla production process including harvesting, processing, packaging and distribution.
ii. **Expertise and Position:** The individuals needed to be in positions of responsibility and have knowledge about the specific factors that contribute to Flat each stage of the SC. These roles included the Director of the Farm, the Export manager, the Production manager, the processing manager and the transporter.
iii. **Ability to Provide in-depth information:** The individuals were chosen based on their ability to provide detailed, first-hand accounts of the processes and challenges involved in producing, handling and distributing the granadillas, with particular emphasis on FL issues.

By focusing on individuals with these qualifications, purposive sampling ensured the study obtained comprehensive and relevant data that contributed to the broad analysis of FL in the granadilla SC.

3.5. DATA COLLECTION

This study used both quantitative and qualitative data collection. The quantitative data were collected to measure the extent of FL along the SC. This involved collecting data from past seasons. This was then quantified using the method derived from the United Nations Economic Commission for Europe (2020).

Additionally, qualitative data were gathered to understand the context, causes, and challenges related to FL from the perspective of key stakeholders. These were collected through semi-structured interviews with the directors, managers, key farm workers, and logistics personnel, a total number of 5 interviews were conducted, lasting approximately an hour each. Examples of themes in the questions included the causes of FL at their particular stage of the supply chain, as well as activities that are currently being undertaken to reduce the FL in their particular stage. These interviews were used to explore their observations, experiences, and practices that contributed to or mitigated FL. Additional shorter interviews were conducted to validate any queries noted from the quantitative data analysis. On-site field observations, lasting approximately 3 weeks were also undertaken on each farm to document post-harvest, storage, and transportation practices as well as conditions that may have influenced FL, such as packaging, storage facilities, and temperature control.

This study heavily relied on historical data from previous harvest cycles due to the seasonal nature of granadilla harvesting and the time constraints of the study. Using historical data enabled the research to capture trends in FL across the SC, providing insights that a single-season analysis might not have revealed. The historical data was sourced from farm production records, pack shed reports and export documentation records, including; harvest logs that detailed the total granadillas planted versus the total granadillas harvested with categories of types of spoilage, post-harvest handling records documenting the quantity of granadillas shipped and received at the pack shed, sorting and grading reports indicating the weights of granadillas rejected and export documents indicating the quantity of granadillas successfully packed and shipped.

While using historical data provided valuable insights, a number of limitations were considered such as data accuracy and consistency. The records were not collected for research purposes, thus variations in data recording may have influenced consistency in data recording, for instance, some employees may have used different criteria to classify granadilla as lost or unsalable, as some of the sorting is done through the discretion of the staff members. Additionally, some records did not provide specific reasons for FL, requiring additional validation through interviews and observations. Lastly, since the study could not track FL over multiple harvests in real time, reliance on historical data meant some recent trends or changes in handling practices may have not been captured. To address these limitations, qualitative insights from further interviews were used to verify trends observed in historical data, ensuring a more comprehensive and contextualised analysis.

3.6. DATA ANALYSIS

The data analysis consisted of quantifying FL at each level of the SC using equations derived from the United Nations Economic Commission for Europe (UNCE) (2020). The UNECE FL measurement methodology was used because it provided a methodical and standardized approach to quantifying FL at different stages of the SC. This methodology was also selected because it aligned with global efforts to FL reduction. Additionally, it allows for the identification of FL at specific stages, which is useful for understanding the key FL loss stages in the granadilla SC.

Each formula used focused on a specific stage of the SC, where FL occurs, making it easier to track and quantify losses from production to distribution. The formulas used also aligned with the use of TOC, which helped to identify the major bottlenecks leading to FL. These included:

At the Harvest Level, the following formulas were used (x represented any food):

i. X Expected Harvest (kg) – X Actually Harvested (kg) = FL
ii. ii. Harvested (kg) – Transported Harvest to the Next Place (kg) = FL II (kg)

This formula was used to estimate pre-harvest loss, accounting for fruits that were expected but not harvested due to factors such as pests or poor weather conditions.

At the post-harvest level, the following formulas were used:

iii. X Harvested (kg) – X Out Sorted, Edible & Unsaleable Produce Due to “Standard” Restriction = Food Loss III (kg) ii. X Transported Produce to Storage (kg) – X Received at Storage (kg) = FL (kg)

This formula was used to quantify losses occurring during or immediately after harvest that may be caused due to fruit damaged during picking or poor handling practices.

At the distribution stage, the following formula was used:

iv. X Produce Set and Intended for Packing (kg) – Actually Packed Produce (kg) = FL V (kg)

This formula was used to quantify losses from sorting, quality control and handling, to identify the percentage of granadillas removed before packaging for export or local sales.

These formulas were applied by collecting numerical data from farm records, and the results were compared with interviews and observations to asses how well they matched. This helped validate the accuracy of the reported losses and provided a more comprehensive understanding of FL at each stage. The final results were then used to classify the severity of losses at each stage, as reflected in the thesis' colour scale.

Once these figures were quantified, a trend analysis was conducted to understand how FL fluctuated across the SC. This analysis focused on identifying patterns over time at each stage, including production, harvesting, storage, distribution, and transportation. This analysis helped identify whether FL increased, decreased, or remained stable over time. Microsoft Excel was used to plot and analyse the trends. Firstly, percentage calculations were applied in Excel to calculate the FL proportions across the different stages of the granadilla SC. Then, combination graphs were used to visualize the FL in the different seasons at each particular stage of the SC, with the bar graphs showing the fluctuations of total granadillas and the line graphs showing the fluctuations of FL across the seasons. Lastly, polynomial trendlines were used to capture the nonlinear nature of FL trends, allowing for a more accurate representation of fluctuation over time. Using a polynomial trendline allowed for better modelling of the FL patterns, as it accounted for variations that a simple linear trendline might not capture. This approach ensured that the trend analysis was data-driven yet validated qualitative insights and therefore improving the accuracy of the findings. By examining these trends, the study aimed to highlight recurring loss issues and understand the seasonal and operational factors affecting FL. This also allowed for the identification of any outliers or anomalies that may have caused increases in FL and examined what contributed to the irregular changes in FL. If extreme values occurred, these were reviewed by comparing them with qualitative insights from interviews. If an outlier was due to a recording error, it was corrected. If it was represented by an actual event, such as a SC disruption it was retained and noted in the analysis. If data was missing from farm records, estimates were based on averages from available data and insights from the interviews to maintain consistency. This provided an additional layer of insight into factors that might have disrupted otherwise predictable patterns.

3.7. ANTICIPATED LIMITATIONS

This study, while aiming to provide a comprehensive analysis of FL within the SC, had several anticipated limitations that may have affected the generalizability and scope of the findings.

i. **Reliance on Self-Reported Data:** The qualitative data in this study relied heavily on self-reported information from stakeholders within the SC, which could have introduced bias. Participants may have under or over-reported certain practices, either unintentionally or due to social desirability, which may have affected the accuracy of the data.

ii. **Heavy Reliance on Past Data:** Due to the seasonal nature of granadilla harvesting and the possibility that the fruit may not have been harvested within the study timeframe, this research relied heavily on historical data from previous harvest cycles. While historical data provided valuable insights into trends and patterns, it may not have fully captured current conditions or any recent changes in harvesting, handling, and storage practices. This reliance on past data may have also affected the accuracy of the findings, particularly if there had been recent changes in supply chain practices or environmental factors such as drought.

iii. **Variability in FL:** Measuring food across the SC posed challenges due to inconsistencies or changes in handling practices and environmental conditions that occurred over the years. Additionally, factors such as fluctuations in temperature or varying storage conditions may have introduced variability that was difficult to control, which could have impacted the precision of the quantitative data.

3.8. ETHICAL CONSIDERATIONS

In conducting this study, a number of ethical considerations will be addressed to ensure the protection of all participants and stakeholders involved:

I. **Informed Consent:** All participants and relevant stakeholders of the Farm will be provided with comprehensive information about the objectives of the study and what data is intended to be looked at. Consent forms will be obtained and handed out to relevant parties, clearly outlining their right to withdraw from the study at any point during the study.

II. **Confidentiality and Anonymity**: To protect the participants and the farm's privacy, all the data collected will be stored securely. Additionally, any dollar values will be altered for the protection of the Farm. Identifying information will be replaced with pseudonyms.

III. **Impact on Farm and Participants:** Efforts will be made to minimize any disruption to the farm's operations and ensure that the study does not adversely affect participants' professional standing.

3.9. SUMMARY

This chapter outlines the research methodology employed in the study on granadilla FL and FW within Everglade's SC. The research adopts a concurrent triangulation design blending both quantitative and qualitative approaches to provide a comprehensive understanding of the subject matter. The study population comprises of employees of Everglades Farm, while the sample size comprises of key stakeholders directly involved in the granadilla SC. The data collection methods include structured interviews with key informants such as the director, production managers, and the export manager, alongside quantitative data on FL at various stages of the SC. This chapter also addresses anticipated limitations such as the reliance on self-reported data, the heavy reliance on past data and the variability in FL. Finally, ethical considerations will be prioritized to ensure that the study adheres to research ethics. Informed consent will be obtained from all participants and confidentiality maintained throughout the research process.

IV. CHAPTER 4: PRESENTATION AND ANALYSIS OF RESULTS

4.1 INTRODUCTION

This chapter presents the findings of the study, with the results of the analysis aligning with the study's objectives. It will begin with presenting the quantitative findings of the data collected through interviews, followed by a presentation of the quantitative findings. Throughout the chapter, a comprehensive assessment of the of degree of the problem, as well as its causes and constraints will be analysed, highlighting the broader impact of granadilla loss on the farm.

4.2. RESPONDENTS IN THE QUALITATIVE STUDY

There were five respondents involved in the qualitative study. These include:

Table 1: Respondents involved in the Qualitative Study

Respondents	Tile/role	Experience
Respondent 1	Farm Director	9 Years
Respondent 2	Export Manager	3 Years
Respondent 3	Granadilla Production/Processing Manager	9 Years
Respondent 4	Production Manager	9 Years
Respondent 5	Transporter	9 Years

4.3. QUALITATIVE DATA PRESENTATION

This section presents the findings from the interviews conducted with key stakeholders involved in the granadilla SC in Sando and Everglades farm. The interviews focused on identifying the causes of FL, strategies for minimizing FL, and the role of collaboration in reducing FL at various stages of the SC.

The responses are organised by each stakeholder group up to the distribution stage, including the directors, the production manager, the pack shed/processing manager, the transport manager and the export manager. These findings provide a foundation for a thematic analysis presented in the subsequent chapter, where key trends and patterns are synthesized.

4.3.1. INTERVIEW RESULTS AND THEMATIC ANALYSIS

A thematic analysis is being employed to analyse the interviews. This method will identify, analyse and interpret patterns and themes.

4.3.1.1 Key Stages of Food Loss in the Supply Chain

The first question asked in the interview alluded to where interviewees believed FL occurred in the SC. To visually depict the stages in the granadilla SC with varying levels of FL, a colour-coded scale has been developed in Figure 6 below based on insights gathered from interviewees. Each stage is represented by a specific colour to signify the severity of FL with red indicating the highest FL, orange indicating mid-level FL and yellow indicating the least.

i. Production Stage (Red)

Interviewees consistently identified the production stage as the point with the most significant FL. This is primarily attributed to factors such as wind damage, which causes fruits to drop and bruise, mechanical damage during transportation, as well as pests and diseases. Consequently, this stage is marked in red to highlight its critical nature within the SC.

For instance, Respondent 2 elaborated on the effects of wind damage, explaining that the primary issue is the dropping of fruit. He noted that this typically occurs during periods of heavy rain and strong winds, which cause a substantial amount of fruit to fall. Once the fruit drops, it cannot be sold because it tends to shrivel.

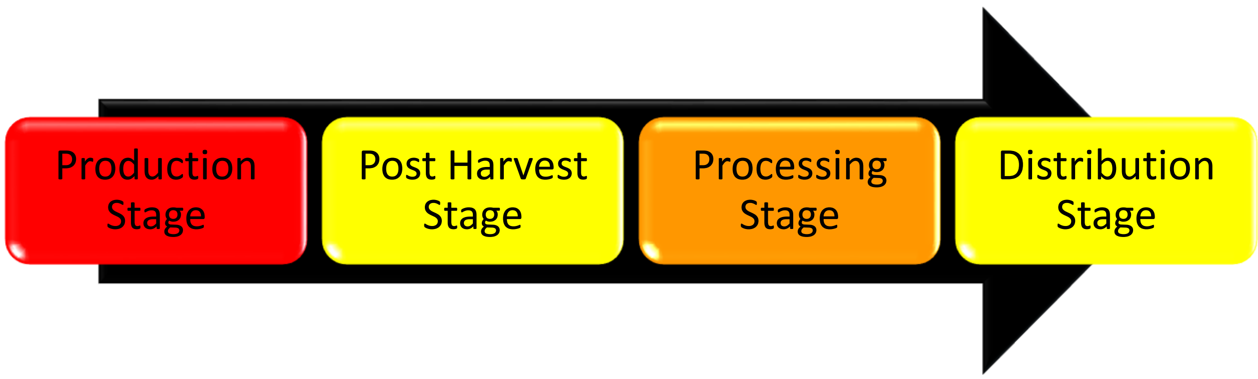

Figure 6: Colour Coded Interview Responses to Stages of the Supply Chain with the most Food Loss

ii. Processing Stage (Orange)

The processing stage experiences moderate FL. According to respondents, losses during this stage are primarily caused by the failure of fruit to change colour, diseases, and insect damage. This stage is marked in orange to signify its intermediate position on the scale.

For instance, Respondent 3 explained that one reason for FL is the failure of fruit to change colour—it remains green. Additionally, respondent 3 mentioned that in order to improve FL along the SC, there needs to be better control of diseases, pests, and viruses in the field. Better handling of the product to prevent damage to the skin before arrival at the pack shed. Constant monitoring of the fruit during the colouring process to ensure it does not overstay and become soft. Continuous cleaning of the machine to prevent any damage to the fruit.

iii. Post-harvest and Distribution Stage (Yellow)

The post-harvest and distribution stages were noted to have the least FL. Factors such as better handling practices, efficient logistics and temperature-controlled storage contribute to these reduced levels of loss. These stages were represented in yellow, denoting their lower impact compared to earlier stages.

For example, Respondent 1 provided an overview of how the post-harvest process is undertaken to reduce FL. He mentioned that, when it is time to harvest, the fruits are picked, placed in boxes, and collected in the shed. Once all the fruits are collected, they are sent to the pack-shed at Sando Farm on the same day. Upon arrival at the pack-shed, the fruits are offloaded, weighed, and placed in the ripening room. Additionally, Respondent 5 mentioned that granadillas are transported at night, often starting between 24:00 and 02:00 hours, in order to keep the temperatures cool. Furthermore, Respondent 5 noted that they ensure there are no gaps between the pallets to prevent the fruits from shaking during transportation. Additionally, when offloading at the airport, they observe the staff's method of unloading, as they tend to make mistakes. These measures have proven effective in reducing FL at these stages of the SC.

4.3.1.2. Causes of Food Loss in the Supply Chain

The second question asked in the interview alluded to what interviewees believe are the main causes of FL along the SC. A tally table illustrated in Table 2 has been created to summarize the most frequently mentioned causes of FL in the granadilla SC, as identified by interviewees.

Table 2: Causes of Food Loss Responses

Causes of Food Loss	Responses
Wind Damage	✓✓
Pests and Diseases	✓✓✓
Tractor Damage	✓
Failure of the fruit to change colour during storage	✓
Delays at the Airport	✓
Movement of Crates on the Truck	✓

Pests and diseases were the most commonly cited cause with three responses. These were particularly prevalent at the production stage, where granadilla crops are most vulnerable. Wind damage was the second most cited cause, with two responses, often occurring during the production stage as well and leading to physical damage to the fruit. Single response causes such as tractor damage, failure of the fruit to change colour during cold storage, delays at the airport and movement of the crates on trucks reflect challenges that occur sporadically but nonetheless contribute to FL. For example, Respondent 1 mentioned that the cause of this FL is primarily due to pests and diseases, as well as mechanical damage. Wind damage is common in August and September, which affects the fruit. Additionally, while the fruit is being sprayed, some of it is accidentally hit by the tractor. The impact of the fruit hitting the ground from the wind or the truck hitting the fruit causes bruising on the fruit, which, therefore, becomes unacceptable to the export market. Past that, the percentages of FL are much lower; however, they can add up by the end of the year.

4.3.1.3. Impact of Food Loss on The Business

Interview findings indicated that the overarching theme of increased costs and decreased profits from reduced exports was a major impact of FL on the business. A substantial portion of granadilla fruit is deemed unfit for export due to quality issues, particularly at the production and processing stages. This reduction in export volume directly limits the business' ability to tap into more lucrative international markets, where profit margins are higher compared to local sales. This leads to decreased profits. The reduction in export capacity translates to a decline in overall business revenue. Since export-grade fruit commands a premium price, the inability to meet export quotas significantly diminishes profit margins. This loss of potential income directly affects the financial sustainability of the business. Lastly, there are increased costs. FL also results in higher operational costs. As mentioned by Respondent 1, losses can be extremely costly for the business, particularly if the FL occurs after the export has been made. This is because the farm pays for packaging and wrapping, which accounts for about 40% of the cost. They also pay for airfreight, which costs more than the entire production. Once FL occurs in the export market, it represents a significant blow to the business. Therefore, the prefer to identify the loss before the goods reach the UK airport, and if they are at the Lusaka airport, they aim to detect it before the plane departs. If FL occurs at the UK border—such as in the rare case that all the fruit has deteriorated by the time it reaches the distributor—Everglades also bear the cost of disposal in that country. As a result, the farm incurs additional losses. Thus, the earlier you can throw away the fruit the better. Respondent 1 also mentioned that some of the fruit is sold locally to the limited market, others are donated to places like schools, hospitals and prisons. However, the majority is thrown away and made into compost, thus further indicating limited probability for Everglades Farm.

4.3.1.4. Constraints in the Supply Chain

A tally table (Table 3) was created to summarize the constraints identified by stakeholders in the granadilla SC. This table highlights the key challenges affecting the efficiency of operations and the quality of the final product.

Table 3: Constraints in the Supply Chain

Constraints	Responses
Phytosanitary Certificate Process	✓✓✓
Water Schedules in the Hot Season	✓
Roads with Multiple Humps	✓
Zesco Challenges	✓
Airport Staff Unloading Incapabilities	✓

As can be seen from the table, the process of obtaining the Phytosanitary Certificate was the most frequently cited constraint, with three respondents emphasizing its complexity and delays. These issues often result in extended lead times, which can affect the freshness and quality of the fruit intended for export. One respondent highlighted that consistent water schedules during the hot season pose a challenge, as granadillas require consistent irrigation to maintain quality and yield. Poor road infrastructure, specifically the presence of humps, was mentioned as a constraint by another respondent. The issue impacts the smooth transportation of granadillas, increasing the likelihood of damage during transport. Power supply issues caused by Zesco were noted by another respondent. These interruptions can hinder operations such as irrigation, processing and storage, negatively affecting the SC. Lastly, one respondent reported that improper handling by airport staff during unloading compromises the quality of the granadillas.

4.3.1.5. Current Food Loss Mitigation Strategies

The findings from the interviews reveal that stakeholders within the SC employ distinct and targeted strategies to mitigate FL at their respective stages of operation. These strategies are reflective of the unique challenges faced at each stage and highlight the individualized approach taken by different stakeholders.

i. Respondent 5

To minimize FL during transportation, transporters focus on reducing the risk of physical damage to the granadillas. Their strategies include: travelling at night, which helps avoid heat exposure that could compromise fruit quality. Additionally, they use forklifts for loading and offloading which ensures minimal handling and reduces the risk of bruising and lastly, tightly packing crates to limit movement during transit, thereby minimizing physical damage to the fruit.

ii. Respondent 4

At the production stage, efforts are directed towards maintaining the quality of the granadillas right in the field. The key strategies include: Monitoring the granadillas daily to ensure they are harvested to optimal ripeness and quality. Additionally, the undertake same-day harvest and storage, which reduces the time the fruit is exposed to environmental factors that could degrade its quality. Lastly, increased efforts are being made to reduce pests and diseases, aiming to minimize contamination and spoilage in the fruits.

iii. Respondent 3

During the processing stage, the primary focus shifts to preserving the granadilla's quality during handling and storage. Key strategies employed include: precooling and after-packing cooling to maintain the fruit at ideal temperatures, minimizing the risk of spoilage, Additionally, cleaning the surfaces, crates and machinery as well as disinfecting colouring rooms and cold rooms to prevent bacterial contamination and ensure a hygienic processing environment.

iv. Respondent 2

For the export stage, reducing FL involves ensuring administrative processes do not delay the shipment of the granadillas. The key strategy is; sorting out all export documents as quickly as possible to reduce delays that would compromise the fruit freshness and quality during extended handling periods.

4.3.1.6. Potential Solutions

Lastly, the findings from the interviews for potential solutions revealed varying perspectives on potential solutions to mitigate FL within the granadilla SC. The proposed solutions highlight both optimism and perceived limitations among the stakeholders, depending on their roles and areas of influence.

i. Respondent 1

Respondent 1 emphasized the importance of value addition as a solution to reduce FL. This approach could involve processing granadillas into products like juice, jams or dried fruit, which could their shelf life and provide alternative revenue streams for fruit that does not meet export standards.

ii. Respondent 4

Respondent 4 expressed a belief that nothing further can be done to mitigate FL at the production stage, suggesting a perceived lack of feasible solutions or satisfaction with current practices. This response may reflect a need for external interventions or new innovations to address challenges in production.

iii. Respondent 3

Respondent 3 identified severable actionable solutions. These included: controlling of diseases, pests, and viruses in the field to reduce the initial causes of FL. Additionally, the processing manager wants to employ better handling of the product to prevent damage to the fruit's skin before it reaches the pack shed, emphasize the need for care during harvesting and transportation. Lastly, the manger suggested constant monitoring of the fruit during the colouring process to ensure optimal conditions to maintain quality and reduce spoilage.

iv. Respondent 2

Respondent 2 highlighted the need to streamline the phytosanitary certificate process which is currently a bottleneck in the export stage. Simplifying or expediting this process could reduce delays and ensure that granadillas are shipped in optimal condition.

v. Respondent 5

Respondent 5 indicated no further solutions are necessary for transportation, as there are no significant issues in this stage. This reflects confidence in the current transportation practices, which already minimize FL effectively.

4.4. QUANTITATIVE DATA PRESENTATION

This section presents the findings from the data collected at Everglades Farm. It includes the results derived from numerical data gathered during the study, such as the loss percentages at key stages, as well as an analysis of contributing factors. By combining these insights with the qualitative findings, the research aims to provide a comprehensive perspective on the matter and determine whether the qualitative and quantitative data align.

i. FOOD LOSS AT THE PRODUCTION STAGE

Data was collected at the production stage of the SC, as this was the primary source of FL. The data spans the past four seasons to analyse the quantities and identify any trends in FL.

The first objective was to collect data from the past four seasons. The data was then organized into different categories and analysed based on the findings. As mentioned in the data analysis section of the thesis, the objective was to quantify the data through the use of the UNECE 2020 Quantifying Food Loss & Waste report. However, some of the equations will be worded to suit the operations of the farm. The first equation was:

X Expected Harvest (kg) – X Actually Harvested (kg) = FFL

The wording used to suit the operations of Everglades is the following:

Total Granadillas Planted (kg) – Total Granadillas Harvested (kg) = FL (kg)

Table 4: Food Loss at the Production Stage

Year/Season	Total Granadillas Planted (kg)	Total Harvested (kg)	Food Loss (kg)	Percentage Loss
2020-2021 Season	673,804	551,294	122,509	18%
2021-2022 Season	512,375	398,104	114,271	22%
2022-2023 Season	723,291	488,682	234,609	32%
2023-2024 Season	322,783	230,465	92,317	29%
Total (∑)	2,232,252	1,668,545	563,707	-
Mean ($\bar{X}$)	558,063	417,136	140,927	25%

Table 4 above shows the calculations of FL at the production stage of the SC. Over the past four years, FL has ranged between 18% to 32% per season with an average loss of 25%. This variability is linked to pests and diseases and wind damage highlighted by Respondent 4 and Respondent 1 in the interviews conducted. When granadillas sell for K30 per kilogram, an average loss of 25% translates to approximately K4,227,810.00 per season.

A further analysis was conducted, and the results are shown in Figure 7 below. This analysis focuses on identifying the primary cause of FL at the production stage of the SC. Both Respondent 1 and Respondent 4 identified two main causes: diseases and fruit dropping due to strong winds. Data was collected to quantify the total amount of FL due to dropping. From this, further data was gathered to determine how much of the dropped fruit was diseased and how much was physically damaged due to bruising or shrivelled and subsequently discarded. The graph clearly shows that fruit dropping was the most significant contributor to FL. Most of the fruit become unsellable due to bruising upon impact or premature shrivelling. This observation aligns with Respondent's 4 explanation.

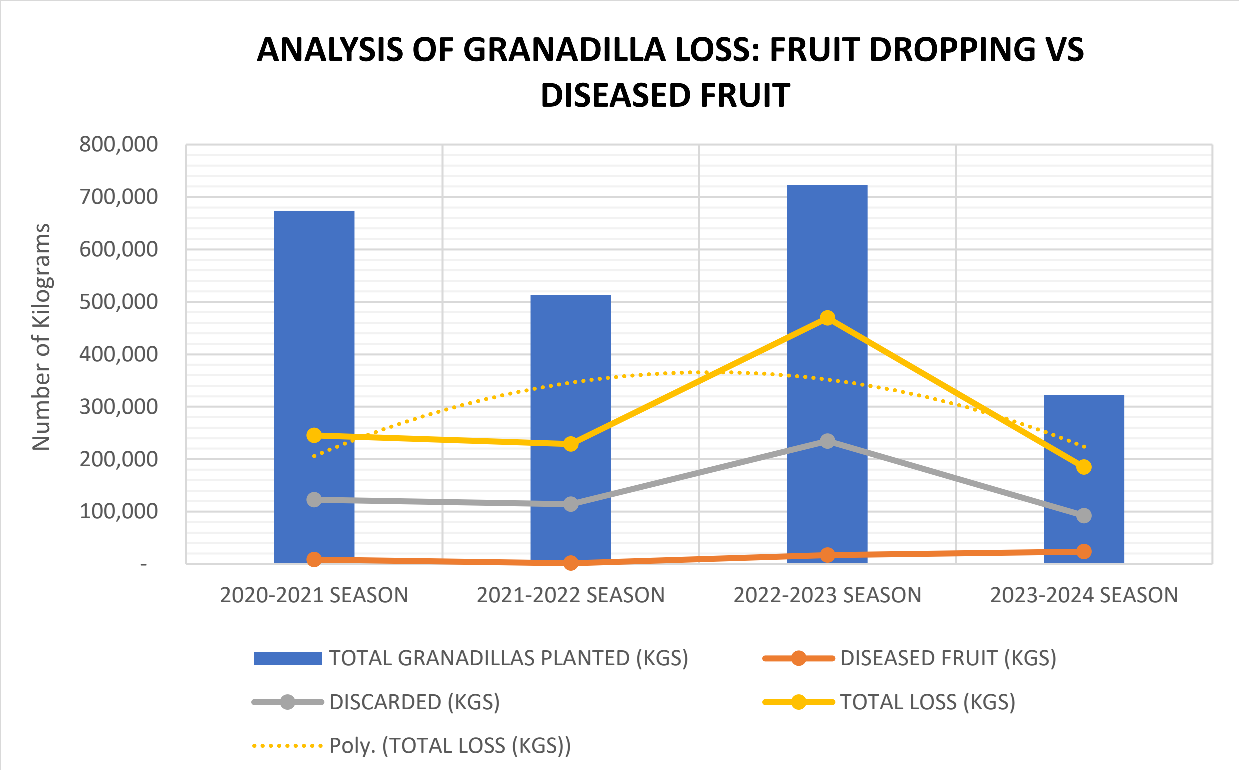

Figure 7: Food Loss Based on Diseased Fruit versus Discarded Fruits

To better understand the relationship between granadilla planting and FL over the four seasons, a combination chart was used to visualize the data. This chart included the total granadillas planted (symbolised by the bar graph) and the total FL (symbolised by the line graph). A polynomial trend line was applied to both datasets to portray the non-linear patterns present in the data.

The analysis revealed significant variability in both the total granadillas planted and the total FL across the seasons. The granadillas planted showed a decrease from approximately 673,803 kilograms (kg) in the 2020–2021 season to 512,375 kg in the 2021–2022 season, followed by a significant increase to 723,291 kg in the 2022–2023 season and then a significant drop to 322,783 kg in the 2023–2024 season. Similarly, FL fluctuated with 122,509 kg lost in the 2020–2021 season, decreasing slightly to 114,271 kg in the 2021–2022 season, peaking at 234,609 kg in the 2022–2023 season then dropping to 92,317 kg in the 2023–2024 season.

The polynomial trend line effectively highlights these rises and falls, illustrating the non-linear relationship between planting and FL. For example, the peak planting season in the 2022–2023 season, corresponds to the highest FL, indicating that increased planting may worsen losses without appropriate intervention. Conversely, the significant decline in planting in the 2023–2024 season is accompanied by the lowest recorded FL, suggesting potential resource constraints or adjustments in production practices.

These findings emphasize the importance of addressing the factors contributing to FL, particularly during years of high production.

ii. Food Loss at the Processing Stage

Data was collected at the Processing stage of the SC to measure the level of FL in comparison to the production stage.

The formular used at this stage was:

X Harvested (Kg) – X Out Sorted; Edible & Unsaleable Produce Due to “Standard” Restriction = FL III (Kg)

The wording to be used to suit the operations of Everglades is the following:

Granadillas Received at Pack shed (kg) - Granadillas Out Sorted, Edible & Unsaleable Produce Due to “Standard” Restriction = FL III

Table 5: Food Loss at the Processing Stage

Year/Season	Received Fruit at Pack Shed (kg)	Accepted Fruit (kg)	Food Lost at Pack Shed (kg)	Percentage Loss
2020-2021 Season	549,268	193,433	355,835	65%
2021-2022 Season	392,341	298,014	94,327	24%
2022-2023 Season	472,132	400,297	71,835	15%
2023-2024 Season	221,174	217,137	4,038	2%
Total (∑)	1,634,915	1,108,880	526,035	-
Mean ($\bar{X}$)	408,729	277,220	131,509	26%

Table 5 above shows the calculations of FL at the processing stage of the SC. Over the past four years, FL has ranged from 2% to 65% per season, with an average loss of 26%. This variability is linked to issues highlighted by Respondent 4, such as the failure of the fruit to change colour, as well as additional damage from diseases and insects. At this stage, the value of the granadillas is higher, as they are getting ready to be exported. Thus, if, for instance, the granadillas are selling for K40 per kilogram, an average loss of 26% translates to approximately K11,088,800 per season.

In analysing the granadilla SC, the quantities of fruit received in the pack shed and the fruit accepted for export and further processing were tracked over four seasons. A comparative trend analysis was conducted to identify patterns and inconsistencies in the SC efficiency and performance at this stage. This is illustrated below in figure 8.

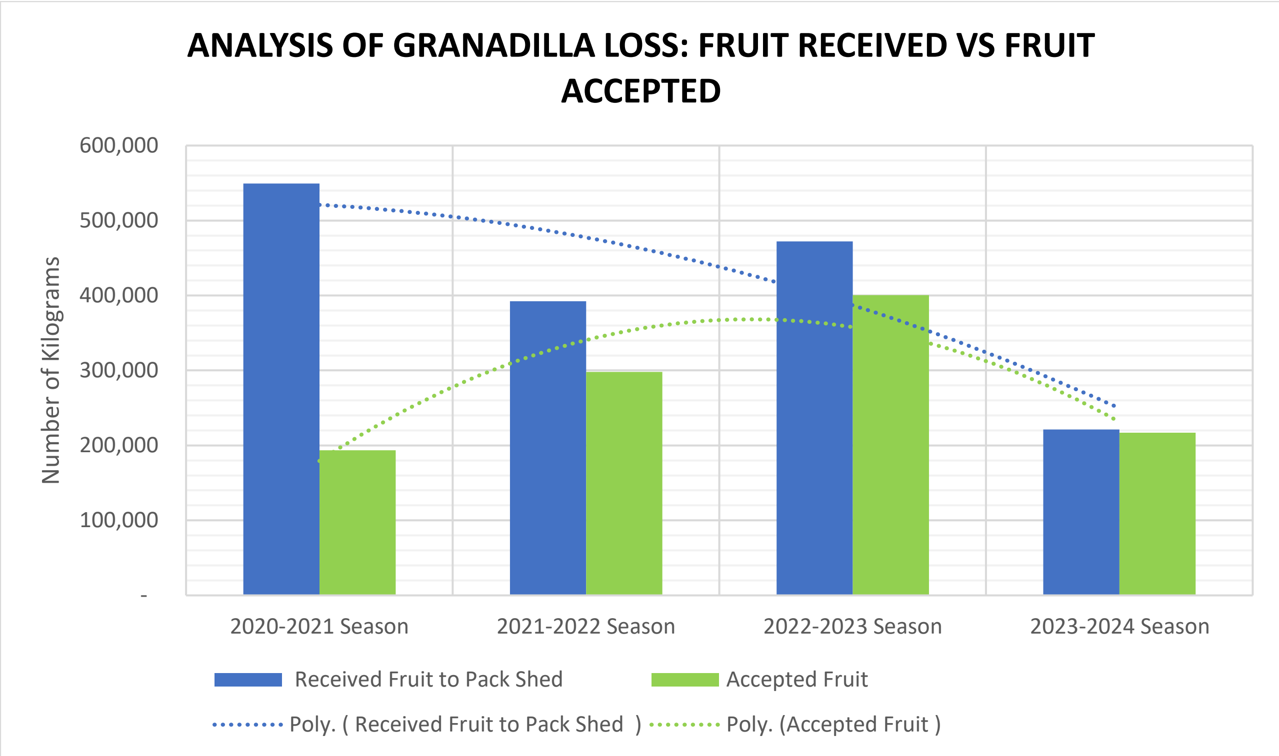

Figure 8: Food Loss Based on Fruit Received versus Fruits Accepted

The data for the 2020-2021 to 2023-2024 seasons highlights the trends in fruit received at the pack shed and the corresponding accepted fruit for sorting. Using a polynomial trendline, the analysis reveals the following insights:

1) Fruits Received

The quantity of the fruit received at the pack shed fluctuates over the season but exhibits an overall declining trend. In the 2020-2021 season, the highest amount of fruit (549,268 kg) was received, while the 2023-2024 season recorded the lowest (221,174kg). The polynomial trendline suggests that the decrease is nonlinear, indicating that external factors such as production constraints or changes in harvest yields may have influenced the trendline.

2) Accepted fruit

The quantity of accepted fruit for further sorting has steadily increased over the seasons, despite fluctuations in the received fruit. The percentage of accepted fruit rose significantly from 35% in 2020-2021 to 98% in 2023-2024. The polynomial trendline for accepted fruit demonstrates a non-linear growth pattern suggesting improvements in quality control and farming practices in the production stage of the SC.

This data highlights an inverse relationship between the total fruit received and the acceptance rate as the total fruit received decreases, the proportion of accepted fruit increases. This could indicate stricter quality measures, standards and procedures during the production stage.

iii. FOOD LOSS AT THE DISTRIBUTION STAGE

Data was collected at the Distribution stage of the SC to measure the level of FL in comparison to the processing stage.

The formular used at this stage was:

X (Kg) Produce Set and Intended for Packing – X (Kg) Actually Packed Produce = Food Loss V (Kg)

The wording used to suit the operations of Everglades is the following:

Granadillas Accepted (kg) – Granadillas packed for Export (kg) = Food Loss

Table 6: Food Loss at the Distribution Stage

Year/Season	Accepted Fruit (kg)	Actual Fruit Packed for Export (kg)	Food Lost for Export (kg)	Percentage Loss (kg)
2020-2021 Season	193,433	171,911	21,522	11%
2021-2022 Season	298,014	251,501	46,513	16%
2022-2023 Season	400,297	380,254	20,043	5%
2023-2024 Season	217,137	205,286	11,850	5%
Total (∑)	1,108,880	1,008,953	99,928	-
Mean (X̄)	277,220	252,238	24,982	9%

Table 6 above shows the calculations of FL at the distribution stage of the SC. In the 2020-2021 season, 89% of the accepted fruit was exported. This showed a strong performance but left 11% of the fruit unexported, indicating untapped export potential. In the 2021-2022 season, the export rate then dropped to 84%. The lower rate could suggest challenges in meeting export requirements or inefficiencies in the process despite a significant increase in accepted fruit. The export rate in the 2023-2024 season stabilised at 95% but the drop in both accepted fruit and exported fruit suggests possible SC constraints and reduced production capacity.

The gap between accepted and exported fruit varies with the largest difference in the 2021-2022 season (46,513kg). This may reflect issues such as stricter export standards, an increase in diseased fruit or an increase in levels of discolouration of the fruit. The smallest gap is in the 2023-2024 season (11,850kg), showing improvements in meeting the export standard, decreased waste and proper handling of the granadillas.

A further analysis was carried and the results are shown in Figure 9 below. The bar graph compares the total fruit accepted at the pack shed for sale with the fruit successfully exported across four seasons (2021-2022 to 2023-2024). The polynomial trend lines offer a more detailed depiction of the fluctuations in both accepted fruit and exported fruit volumes over time.

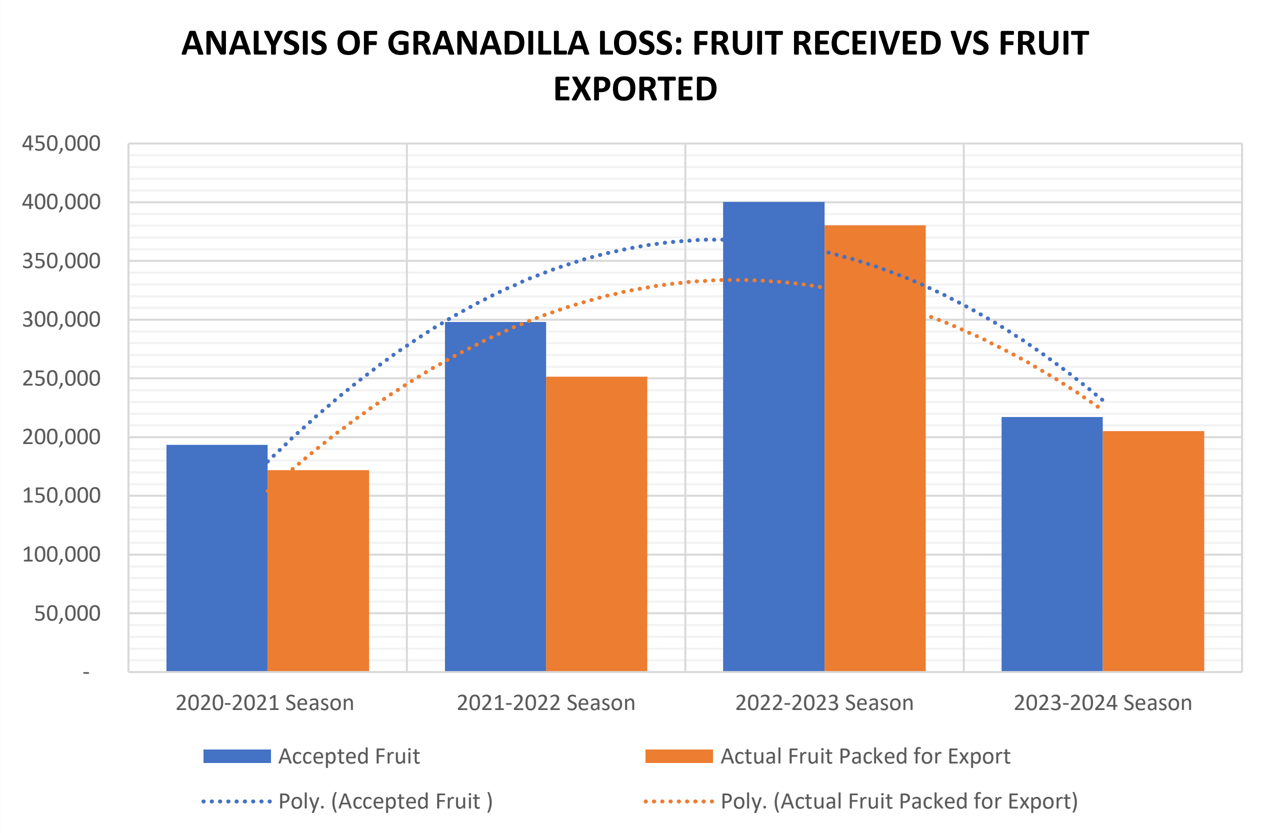

Figure 9: Food Loss Based on Fruit Received versus Fruits Exported

The polynomial trend lines indicate a non-linear relationship. The trend for accepted fruit shows an initial steady rise peaking in the 2022-2023 season, followed by a sharp decline in the 2023-2024 season. This pattern aligns with the planting capacity shown in Table 4. Similarly, the trend for exported fruit closely mirrors the accepted fruit trend but consistently falls below it, reflecting the unutilized export capacity of the granadillas. The polynomial curves highlight that, while there was a significant increase in export volumes up to the 2022-2023 season, then a subsequent decline in 2023-2024 points to potential constraints in production. The gap between the two trend lines represents the unexported fruit emphasizing the opportunity loss – the fruit that met the pack shed's acceptance standards but was not exported. This loss underscores the snowball effect of inefficiencies in the SC, from the causes of FL in the production stage to the processing stage, ultimately reducing export capacity.

4.5 SUMMARY

This chapter outlined the results of the study conducted at Everglades Farm, incorporating both qualitative and quantitative analyses to provide a well-rounded understanding of the granadilla SC. Insights from interviews, done as part of qualitative analysis, with key SC stakeholders revealed critical challenges, constraints and opportunities within the system. The findings emphasized the main stages where FL occurs, particularly in production and processing. The quantitative analysis complements these findings by presenting numerical data collected on FL and the opportunity loss at different stages of the SC. Key equations were analysed and visualized using bar graphs and trend lines. Together the qualitative and quantitative analyses provided a holistic view of the granadilla SC at Everglades Farm, identifying areas for improvement and opportunities for reducing unutilized export capacity.

V. CHAPTER 5: DISCUSSION OF FINDINGS

This chapter interprets the study's results in relation to the research objectives and existing literature. It examines the key stages in the granadilla SC where FL occur, it evaluates the primary causes of this FL based on the findings, it evaluates the impact the FL has on the business and lastly evaluates the strategies that are currently being used to reduce FL on the farm, as well as identifies the strengths of the farm.

This study aimed to explore the extent of FL at various stages of the granadilla SC on Everglades farm in Mkushi, Zambia. The findings reveal that most FL occurs at two stages: production and processing. During production, losses are primarily due to environmental factors such as strong winds as highlighted by the director and production manager and supported by quantitative data. Strong winds cause premature fruit to drop, causing bruising and physical damage making the fruit unsuitable for export. This in turn, increases the volume of fruit rejected at later stages, as damaged fruit is more susceptible to spoilage during handling and transport. At the processing stage, a significant portion of fruit is discarded or donated as it fails to meet export standards, further emphasizing the importance of maintaining fruit quality throughout the earlier stages. The failure to meet quality standards in production, compounds the challenges at processing, creating a cascading effect of FL across the SC. These results underscore the importance of quality control measures in the granadilla SC. The high rate of loss at the processing stage reflects a broader trend observed in sub-Saharan Africa, where export-oriented supply chains often face stringent quality requirements. Furthermore, the export process itself presents a constraint, with the lengthy and tedious process of obtaining the phytosanitary certificates causing delays and inefficiencies.

In the context of sub-Saharan Africa, FL and FW occur at various stages of the SC, with approximately 10% of FL occurring at the agricultural stage, 8% at the post-harvest stage, 20% at the processing stage, 10% at the distribution stage, and 14% at the consumption stage. The findings from the case study reveal that the farm's production stage experiences an average loss of 25%, resulting in a financial cost of approximately K4,227,810 per season. This figure represents a significant financial burden, especially when compounded over multiple seasons. Notably, this loss is higher than the sub-Saharan Africa benchmark of 10% for FL at the production stage, underscoring the need for targeted interventions. At the processing stage, the farm experiences a loss rate of approximately 26%, valuing at a cost of K11,088,800 per season. While the loss rate is only slightly higher than the sub-Saharan African benchmark of 20%, it still represents a substantial cost to Everglades, worsening the financial burden. At the distribution stage, the loss is not considered a “loss” per se, however, it translates to lower export capacities as 9% of the fruit cannot be exported which translates to a value of approximately $374,730 or K10,117,710 (at a rate of K27 per dollar). This loss is slightly lower than the regional benchmark of 10%. Looking at the SC as a whole, it can be seen that Everglades has an export capacity of approximately 48% as seen in Table 7 below. The export capacity in this case is the proportion of total production of granadillas that meets export requirements. This serves as a key measure of SC efficiency and overall profitability. Currently the farm exports about 48% of its production, revealing a considerable gap between total production and output deemed suitable for export.

Table 7: Everglades Export Capacity

Year/Season	Total Granadillas Planted (kg)	Actual Fruit Packed for Export (kg)	Export Capacity (%)
2020-2021 Season	673,804	171,911	26%
2021-2022 Season	512,375	251,501	49%
2022-2023 Season	723,291	380,254	53%
2023-2024 Season	322,783	205,286	64%
Total (∑)	2,232,253	1,008,952	-
Mean ($\bar{X}$)	558,063	252,238	48%

This suggests that more than half of the farm’s production does not meet export standards. As mentioned previously Gustavssin et al., (2011), noted that, product exclusion is a significant factor in FL, influenced by various aspects of the fruit, such as improper weight and size, discolouration, and damage. Thus, with only 48% of production being exported, the farm faces significant revenue losses as export-grade granadillas command higher prices in international markets compared to local sales. Increasing export capacity could therefore enhance profitability by tapping into the higher value of export markets. This could mean that the Farm needs to look into more of the high FL areas and try to mitigate the issues and increase their export capacity, thereby increasing their revenues, especially as the value generated from the exports is higher than the value generated from local sales.

Using the Theory of Constraints (TOC) framework, several critical bottlenecks were identified across the granadilla SC, particularly at the production, storage, and distribution stages. At the production stage, three major constraints were highlighted: pests and diseases, wind damage, and mechanical damage. These issues collectively contribute to significant FL by reducing yield quality and marketability. For example, pests and diseases directly affect fruit health, while wind damage causes premature fruit drop, and mechanical damage during harvesting affects the physical appearance of the fruit. These constraints pose substantial challenges to achieving export-grade standards, thereby limiting the farm's profitability. At the storage stage, a key constraint is the failure of granadillas to achieve the appropriate export-grade colour during storage. This issue impacts the farm's ability to meet export requirements, as fruit colour is a critical quality parameter for export markets. At the distribution stage, the primary constraint is the complex and time-consuming process of obtaining phytosanitary certificates. These delays result can sometimes result in missed export windows and fruit deterioration, further limiting the farm's competitiveness in international markets. Although these constraints highlight significant challenges, tackling them will require targeted interventions at each stage of the SC. The recommendations section provides an in-depth analysis of potential solutions.

A notable strength of Everglade's operations is its strong SC collaboration. Observations and interviews with SC stakeholders show that all parties are trained to value timeliness in their specific roles and maintain effective communication. Employees consistently arrive on time for harvesting and packing the fruit onto the truck. Workers at the pack shed are efficient in the sorting process, while the transporter is punctual and well-informed about delivery schedules. The export manager maintains clear and prompt communication with the airport staff. Overall, all team members make a concerted effort to ensure their responsibilities are completed on time. Therefore, the farm's current strengths—particularly its use of SC collaboration—can be leveraged to address these challenges. The high level of communication and timeliness observed among stakeholders suggests that further collaboration could help mitigate some of these bottlenecks. For example, better scheduling between the processing team and the export team—ensuring that all exports are completed between Monday and Friday could help reduce weekend delays. Additionally, collaboration with Zambian government systems to streamline the phytosanitary certificate process, through constant feedback to remove any bugs, could further ensure efficiency in the export process. Another notable strength of the farm was their current mitigation strategies such as temperature control across the SC, and their use of export worth packaging for the granadillas to ensure the quality of granadillas is maintained as it travels through the SC.

Addressing these bottlenecks and constraints calls for a holistic approach that combines better resource management with streamlined procedures. By addressing these aspects, the farm can strengthen its SC resilience, minimize FL and enhance its competitiveness in the export market.

VI. CHAPTER 6: RECOMMENDATIONS AND CONCLUSION

In this final chapter, recommendations will be highlighted on how the farm can improve FL across the SC. The qualitative and quantitative insights were crucial in shaping the recommendations for mitigating FL across the SC.

6.1. RECOMMENDATIONS

In the qualitative findings, it was noted that the main stage of FL was the production stage. It was further mentioned that the cause of FL at this stage was pests and diseases and wind damage. Thus, in response to the major contributor of FL, the TOC framework will be used. As mentioned in the literature review, the key steps in the literature review are identifying the constraints, exploiting the constraint, subordinating the other processes, elevating the constraint and repeating the process. An example of this is as follows:

Identifying the Main constraint: The production stage has been identified as one of the primary constraints in the granadilla SC, with pests and diseases as well as wind damage being major contributors to FL.

Exploiting the Constraint: This could be undertaken by implementing integrated pest management through identifying key pests and diseases, and disease management. Like the example of the Malaysian commercial granadilla project that failed and then had a significant turnaround due to research into fungal control, Everglades farm can follow suit. The farm could start by undertaking research into the various pests and diseases that affect the quality of their fruit and look into best practices and efforts to solve it. As mentioned in the literature review, additional studies have been conducted, and comprehensive manuals have been developed by organizations such as USAID (2019) to address the prevention and management of various diseases and pests that affect granadilla production. Thus, Everglades could benefit from these resources. Additionally, as efforts are already being undertaken to counter this problem, they could include pest scouting schedules for early identification of outbreaks through workers inspecting the plants weekly during peak pest and disease season to catch the pest and disease early. Additionally, for wind damage, protective measures can be undertaken such as lightweight mesh netting or rows to shield the granadilla vines from wind stress during critical growth periods. These strategies exploit the constraint by reducing FL caused by pests, diseases and wind damage without significant changes to production practices as well as without increasing usable yield from existing production resources.

Subordinating other processes: This can be undertaken by, in the instance of pests and diseases, more workers can be allocated for pest scouting and treatment during high-risk months. Additionally for wind damage, the farm could subordinate planting patterns to minimize wind exposure. This could be done by arranging rows perpendicular to prevailing wind directions to reduce direct impact on the vines. Subordination will ensure that processes downstream of the constraint do not worsen losses caused by wind damage, pests and diseases.

Elevating the constraint: This strategy means that Everglades can invest in resources or technology to overcome the constraint permanently. This could mean investments in disease-resistant granadilla varieties such as the yellow granadilla (Passiflora edulis f. flavicarpa). According to Correia et al (2022), this granadilla is considered a disease resistant than the purple granadillas that Everglades Farm currently uses. This could drastically reduce the need for treatments. Additionally, the farm could transition towards more controlled environment agriculture such as greenhouses to limit pest infestation and disease as well as limit the impact of wind damage. Additionally, more advanced monitoring tools can be used such as drone technology or sensors to detect outbreaks early. For instance, drones with thermal imaging could spot infected plants before visible symptoms appear. Elevating the constraint through these investments could drastically reduce losses ensuring higher quality outputs and improved profitability.

Repeating the process: As has been mentioned, continuously identifying and addressing the bottleneck can help optimize the entire system and prevent FL from occurring at different stages. Thus, this process can be done with each constraint along the SC, until the SC is efficient and effective and the farm reaches higher levels of export outputs.

One way to keep track of this is using an example of Figure 10 below created by Bartezzaghi et al, 2022. The figure lists down all the causes of FL as well and ticks at what stage of the SC they often occur. Using a colour-coding method noting the priority of action with red being high priority, yellow being medium priority and the unshaded showing the lowest priority.

	CAUSES OF SURPLUS FOOD AND FOOD WASTE	FSC STAGE				
		Agricultural Production	Handling Storage	Processing and Packaging	Distribution	Retail
1	Non-conformity to quality specifications	✓	✓	✓	✓	✓
2	Lack of coordination and information sharing	✓	✓	✓	✓	✓
3	Product quality deterioration due to diseases, pest or contamination	✓	✓	✓	✓	✓
4	Poor operational performance	✓	✓	✓	✓	✓
5	Overproduction; oversupply; excessive stock	✓	✓	✓	✓	✓
6	Short product shelf-life; near expiry products	✓	✓	✓	✓	✓
7	Lack of appropriate storage facilities and cold chain facilities		✓	✓	✓	✓
8	Inadequate or defective packaging		✓	✓	✓	✓
9	Inadequate demand forecastig; unpredictable orders	✓	✓	✓	✓	✓
10	Storage at wrong temperatures		✓	✓	✓	✓
11	Inadequate transportation management	✓	✓	✓	✓	
12	Inadequate agronomic practices; inadequate harvest scheduling	✓	✓	✓	✓	
13	Weather variability - extreme weather	✓	✓			
14	Consumer education on food losses; consumer intolerance of substandard			✓		✓
15	Not-harvested products due to unprofitable market prices	✓				
16	Transportation at wrong temperatures				✓	
17	Pricing strategies and promotions management	✓	✓	✓		✓
18	Buyer availability	✓	✓		✓	✓
19	Take back agreements and orders cancellation			✓	✓	
20	Inadequate inventory and storage management		✓	✓		
21	Changing consumer tastes and demand over years	✓	✓	✓	✓	✓
22	Risk of rejection	✓				
23	Distance travelled				✓	
24	Inadequate handling by consumers					✓
25	Inefficient in-store management					✓
26	Impossibility of repacking if one item becomes diseased or out of standard					✓
27	Trimming			✓		

Figure 10: Causes of Food Loss and at each Stage of the Food Supply Chain (Bartezzaghi et al, 2022)

Everglades can implement this method across the entire SC noting the causes, and the priority and use the TOC method to address the constraint.

Using the Decision Synchronisation explained in the SC collaborative theory, could be an added advantage to identifying and mitigating these constraints. By addressing bottlenecks at each stage of the SC and fostering collaboration among actors, resources can be effectively utilized to resolve these issues. This approach also aligns with Systems Theory, as it considers the SC as a network of interdependent actions. For instance. Action taken at the production stage directly influence the quality and acceptability of the fruit at the processing stage. By addressing constraints at the production stage, a domino effect can be created, leading to positive impacts on subsequent stages.

Another recommendation to address the issue of granadilla fruit losses is that the farm invest in value addition by diversifying the use of granadillas into other products. This approach could reduce dependency on export-grade fruit while creating alternative streams of income for fruit that is not acceptable for export or sale, but is safe to consume. These could include products such jams, juices or dried fruit granadilla snacks. However, to do this the farm needs to invest in processing equipment and train staff on how to use the equipment, therefore this may not be a short-term goal, but a long-term goal. By implementing these value-addition strategies, the farm can significantly reduce FL, reduce costs and enhance profitability. Furthermore, these initiatives will strengthen the granadilla SC by promoting sustainability and resilience in the face of export constraints.

6.2. CONCLUSION

This study set out to investigate FL and FW within the granadilla SC, focusing on key stages, primary causes, business impacts and strategies for reduction. The findings provide valuable insights into the challenges faced by the farm and opportunities for improvement.

The analysis revealed that the majority of FL occurs at the production stage due to issues such as pests and diseases, wind damage and mechanical damage. Losses were also noted at the processing stage, primarily due to the granadilla not changing to the correct colour and stringent export standards which classify a significant portion of the fruit as non-exportable. Other constraints such as the phytosanitary certificate process, were also noted as areas of improvement, that if not addressed could lead to increased FL, through deterioration of the fruit. Quantifying the levels of FL and FW highlighted a substantial impact on the farm's profitability. A significant portion of granadilla fruit is unfit for export leading to reduced revenue potential. Losses at various stages also contribute to inefficiencies and underutilization of resources, emphasizing the need for targeted interventions. Existing strategies to mitigate FL include same-day harvesting and storage, night transportation to keep the fruits at a cold temperature as well as cold storage. SC collaboration also proved to be a strength of Everglades. Lastly, to reduce FL and FW the farm should undertake a TOC approach to address constraints, additionally, they could consider adopting value-addition strategies, such as producing granadilla-based products and improving processing infrastructure.

In conclusion, addressing FL and Waste in the granadilla SC requires a comprehensive approach that combines improved practices, value-addition and infrastructure development. By implementing these strategies, the farm can enhance sustainability, profitability and resilience within the SC.

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VIII. APPENDIX

Interview Questions

Interview with the Farm Director

Question 1: Could you give me an overview of how your granadilla supply chain works?

Question 2: At which stage of the granadilla supply chain do you experience the most FL?

Question 3: What do you think is the main cause of this FL?

Question 4: What actions do you currently carry out to reduce FL at each stage of the supply chain?

Question 5: What happens to the fruits that cannot be sold or exported?

Question 6: Have you looked into any value-addition systems to help with the fruit that cannot be exported?

Question 7: Have you considered using refrigerated trucks?

Question 8: What do you think about the collaboration among all the stakeholders in the granadilla supply chain?

Question 9: Do you track your FL along the supply chain?

Question 10: What impact does the FL have on the business?

Interview with the Export Manager

Question 1: Why is there a constraint in exporting the fruit?

Question 2: Do you think this process can be improved?

Question 3: How is the collaboration between you and the relevant authorities involved in the export process?

Question 4: What changes do you think need to be made in order to create a smoother flow of the export process?

Interview with the Granadilla Production Manager

Question 1: Could you give me an overview of the production side of the granadillas?

Question 2: What do you think is the main cause of granadilla loss on the production side of the supply chain?

Question 3: I was informed that pests and diseases are also a cause of FL in the production stage. Would you agree?

Question 4: How do you mitigate this loss?

Question 5: How often do you monitor the granadillas?

Question 6: What do you do to the fruit that drops?

Question 7: What do you do to the diseased fruit?

Question 8: How many people are involved in the picking/harvesting?

Question 9: Are they all trained?

Question 10: How often do you monitor the granadillas?

Question 11: Are there any constraints?

Interview with the Production Manager

Question 1: Could you briefly provide a breakdown of the process at the pack shed?

Question 2: What do you think is the main cause of the granadilla loss during the sorting and packing process?

Question 3: Do delays occur during the process? If so, what are the causes of these delays?

Question 4: What measures do you take to prevent the deterioration of the fruit?

Question 5: What improvements do you think could help reduce the granadilla loss?

Interview with the Transporter

Question 1: How is the granadilla fruit loaded and unloaded from the truck?

Question 2: Are there any specific precautions taken to minimize damage during loading and unloading?

Question 3: What type of storage system is used in the truck (e.g., temperature control, ventilation) and how do you ensure that the granadillas remain fresh during transportation?

Question 4: How long does it usually take to transport the granadillas to their destination?

Question 5: What is the condition of the roads you typically use for these trips?

Question 6: What do you think is the main cause of FL in the distribution stage?

Similarity Report

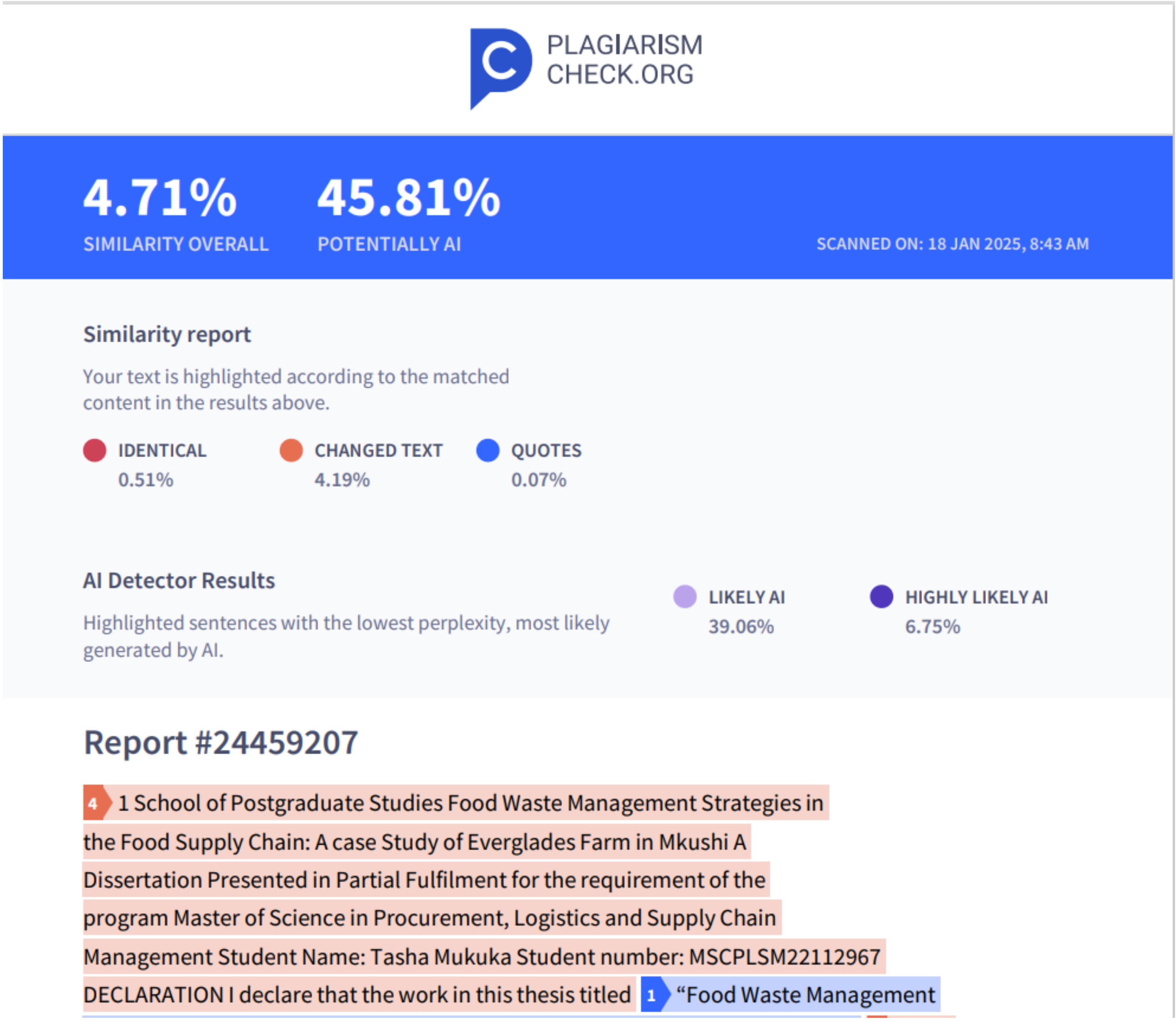

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Figure 11: Similarity Report