ESTIMATION OF POST-HARVEST LOSSES ON VEGETABLE VALUE CHAIN IN LUSAKA OPEN MARKET

BY

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The University of Zambia approves this Dissertation by JOSEPHINE MWAMBA on "Estimation of Post-Harvest Losses on Vegetable Value Chain in Lusaka Open Market" in partial fulfilment for the requirements for the award of the Degree of Master of Science in Human Geography.

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ABSTRACT

Vegetables are highly perishable and lack of storage facilities affects their marketability. Once vegetables are separated from their source of nutrients (plant) they undergo higher rates of respiration, resulting in moisture loss, quality and nutrient degradation, and potential microbial spoilage (Alegbeleye et el, 2022). Post-harvest losses (PHLs) contributes to organic waste in the market. Hence, Post-harvest food loss is a contributor to food insecurity in Zambia. The aim of this study was to estimate post-harvest loss on vegetable value chain in Lusaka city region, Zambia. The objectives of this study was to estimate the quantity of food losses at various nodes of the vegetable value chain in Lusaka city region, to investigate the main causes of post-harvest losses and coping mechanisms being used to reduce the losses at the retail stages. An instrumental case study design was employed in seven districts of Lusaka city food region using secondary quantitative data from the Africities Food Project, and primary qualitative data from purposively sampled local market authorities and retailers at Soweto open market in Lusaka city. The data was analyzed through thematic analysis and descriptive statistics using Minitab software. The results showed the quality loss of tomatoes to be 68.6%, and the loss of fresh vegetables to be 66.1%. The common causes of post-harvest losses in Lusaka region were mishandling (22.9%), high temperatures (20.1%), lack of storage facilities (17%), and pests or disease attacks (13.9%). Coping mechanisms employed were keeping the produce cool to avoid damage by the sun (23%), separating the injured, diseased or decayed produce from the fine produce (21%), proper clean storage (18%), avoid injury at all costs (15%), assess maturity and quality of produce immediately the produce arrives at the market (13%), and drying (10%). Post-Harvest Loss (PHL) of vegetables is considered to be a major problem for farmers and other actors' involved along their supply chain. To reduce the post-harvest losses of vegetables, agricultural training and extension services should be given to farmers and other actors on proper pre harvest practice, postharvest handling, type of packaging used, transportation system and storage condition and marketing systems.

DEDICATION

I dedicate my work to my loving mother, Mrs Josephine Mubanga Mwamba for her wonderful guidance and discipline which has made me the person I am today. To the Almighty God, my Elohim Azar, protector, provider, and source of wisdom and strength, who continues to remind me that with him all things are possible. To him be honour and all the glory.

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LIST OF ABBREVIATIONS AND ACRONYMS

CSO	Central Statistical Office
CAGR	Compound Annual Growth Rate
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
LCC	Lusaka City Council
PHL	Post-Harvest Loss(es)
UNEP	United Nations Environment Programme
UNICEF	United Nations International Children's Emergency Fund
UNZA	University of Zambia
US	United States
USDA	United States Department of Agriculture
WHO	World Health Organization
ZMD	Zambia Meteorological Department

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Global vegetable production has increased by 65% between 2000 and 2019 from 2 031 616.8 to 3 511 294.4 tonnes (Food and Agriculture Organization [FAO], 2021). In 2019, the production of vegetables was 1128 million tonnes globally, 84 million tonnes for Africa and about 0.47 million tonnes for Zambia (FAO, 2021). Vegetables are an essential part of the daily meals. According to Gubben et al. (2014), the most important market vegetables in quantity and value are tomatoes, onions, and hot peppers, because they are used daily. Leafy vegetables generally contain higher amounts of nutrients per g dry matter than non-leafy vegetables and they are rich in proteins as legumes (Gubben et al., 2014). Therefore, the production of vegetables requires attention even after harvest due to Post-Harvest Losses (PHL).

Nearly on a daily basis vegetables are lost at different stages of the vegetable value chain. Post-Harvest Losses (PHL) are very high with 44% of fresh vegetable loss and about 30% of vegetables are rendered unfit for consumption due to spoilage after harvesting (Batziakas et al., 2020). According to Kiaya (2014), PHL can be defined as the degradation in both quantity and quality of a food production from harvest to consumption. Quality losses include those that affect the nutrient/caloric composition, the acceptability, and the edibility of a given product. Quantity losses refer to those that result in the loss of the amount of a product. Loss of quantity of vegetables is more common in developing countries (Guru and Mishra, 2017). Hence, both quantitative and qualitative food losses of extremely variable magnitude occur at all stages in the post-harvest system from harvesting, through handling, storage, processing and marketing to final delivery to the consumer.

According to Guru and Mishra (2017) vegetables are living plant parts containing 65 to 95 percent water, and they continue their living processes after harvest. Crops like tomatoes and fresh vegetables undergo PHLs more rapidly compared to root crops. Their post-harvest life depends on the rate at which they use up their stored food reserves and their rate of water loss. When food and water reserves are exhausted, the produce dies and decays. Anything that increases the rate of this process may make the produce inedible to consumers. In addition, water loss causes shrinkage and loss of weight in vegetables as they lose water quickly because they have a thin skin with many pores which causes water to evaporate quickly. Hence, PHL of vegetables reduce the availability of valuable substances found in vegetables.

A report by FAO (2014) indicated that up to a third of the food produced is lost between harvest and the consumer, amounting to 1.3 billion tonnes per year with an estimated value of US$ 310 billion. PHL are important throughout the food system and the level of PHL varies by commodity, season, geography, culture, socio-economic circumstances, step of the value chain and postharvest system (Bechoff et al., 2019). Hence, PHLs becomes a huge loss of valuable food when the minimum food requirement of the population is not met. Globally, about 40 and 50% of losses are fruits and vegetables, of which 54% occur in stages of production, post-harvest, handling and storage, while 46% occur in processing, distribution and consumption, with a total annual loss of US$750 billion (Gustavsson et al., 2011). This indicates that vegetables such as tomatoes and cabbages are among the vegetables that are lost as they are highly perishable and increases the loss of nutrients. According to the United Nations International Children's Emergency Fund (UNICEF) and World Health Organization (WHO) (2017) in 2016, one in five deaths were associated with poor diets. Without urgent policy action, that ratio is likely to worsen rapidly in coming decades. Thus, vegetable loss and waste are a global problem and a major concern at all stages.

PHL are a global problem, and despite the advances made to improve production volumes at least 33% of all agricultural produce never reaches the 30 consumers (Gustavsson et al., 2011). Regional data on combined fruit and vegetable losses show that all regions across the globe lose at least 20% of their fresh produce to PHL with extreme losses of 45 – 50% being reported in Africa and Asia respectively (Olaerts, 2023). A variety of factors contribute to PHL, the importance of which differs from product to product, from season to season, and to the broad variety of conditions under which commodities are grown, harvested, stored, processed and marketed. Regardless of their location, PHL have a cumulative effect, contributing to waste and food insufficiency.

In many African countries, the PHL of food cereals are estimated at 25% of the total crop harvested. For some crops such as fruits, vegetables and root crops, being less hardy than cereals, PHL can reach 50% (Mtui, 2017). The causes of food losses and waste especially with vegetables in low-income countries are mainly connected to financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult climatic conditions, infrastructure, packaging and marketing systems (FAO, 2011). Given that many smallholder farmers in Africa live on the margins of food insecurity, a reduction in food losses could have an immediate and significant impact on their livelihoods.

Postharvest vegetable loss is a major concern in Zambia. PHL increases hunger by causing less food to be available for consumption. Consumers are deprived of getting a premium product for every qualitative loss. When 30% of a harvest is lost, 30% of all the factors that contributed to producing the crop are also wasted (Phiri, 2010). Vegetable production utilizes various forms of mechanical energy. This energy is required for ploughing, planting, applying agrochemicals, irrigating, harvesting, refrigeration, transporting, food processing, and packaging of vegetables (James and Zikankuba, 2017). As a result, reducing PHL is a practical way to ensure mechanical energy by the farmer is not wasted and ensuring more of the increasingly valuable harvested food is available for human consumption.

1.2 Statement of the Problem

Vegetables are highly perishable and lack of storage facilities affects their marketability. Once vegetables are separated from their source of nutrients (plant) they undergo higher rates of respiration, resulting in moisture loss, quality and nutrient degradation, and potential microbial spoilage. According to Batziakas et al. (2020), most vegetables lose 30 percent of nutrients three days after harvest, on the conservative side. Vegetables can lose 15 to 55 percent of vitamin C, for instance, Spinach can lose 90 percent within the first 48 hours after harvest (Batziakas et al., 2020). In addition, PHL also affects the retailers economically due to price fluctuations, profit margins and organic waste in the market. Hence, Post-harvest food loss is a contributor to food insecurity in Zambia.

PHL and waste of food across the globe are both large and significant. In Zambia, PHL contributes to the reduction of food supply and, hence, leads to high food prices in the market and thereby aggravating the food insecurity situation in the country. The main reasons of PHL among others is inherent weaknesses in post-harvest handling techniques due to the poor management practices, lack of infrastructure, appropriate equipment's and limited access to market. There is inadequate information on vegetable postharvest losses in Zambia particularly in Lusaka city region. This could be a source of information on the impact of this problem, therefore this study sought to estimate PHL on vegetable value chain in Lusaka.

1.3 Significance of the Study

This study will help educate the farmers and general residents on the proper handling of vegetables to avoid the losses at any stage of the chain. It will create a platform that will promote investing on storage infrastructure to prevent the food losses. Thus, it will strengthen the policy maker at national level to formulate policies that would improve the open market to help avoid wastage through the coping mechanisms. The study will also motivate stakeholders to provide the necessary assistance that would promote preserving of vegetables to reduce the losses especially at the retail stage. Lastly, it has contributed to the literature on PHL.

1.4 General objective

To estimate post-harvest losses on the vegetable value chain in Lusaka city region, Zambia.

1.5 Specific objectives

i. To estimate the quantity of food losses at various nodes of the vegetable value chain in Lusaka region.
ii. To investigate the main causes of Post-Harvest Losses.
iii. To investigate the coping mechanisms being used to reduce the losses at the retail stages.

1.6 Research Questions

i. What is the quantity of vegetable loss from harvest to packaging for transportation of the selected vegetables?
ii. What is the quantity of vegetable loss during transportation of the selected vegetables?
iii. What is the quantity of vegetable loss at the retail of selected vegetables?
iv. What are the causes of post-harvest losses?
v. What strategies are being used to minimize vegetable losses among retailers in an open market?

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Postharvest vegetable loss is a global problem, affecting both developed and developing countries. The focus of this study is on the estimation of post-harvest losses on vegetable value chain in Lusaka, Zambia.

2.1 Global perspective

A diversity of vegetables is grown all over the world for their nutritional value, test and cuisine. According to FAO (2022) the Indian fresh vegetable market was valued at $152.3 billion in 2021 and is projected to grow at a compound annual growth rate (CAGR) of 4.5% from 2022 to 2028. Despite its agricultural output, nearly 12% to 30% of vegetables are lost annually after harvest, undermining food security and farmer incomes. This implies that in order to archive food and nutrition security worldwide there is need to reduce post-harvest losses. Reducing food losses therefore offers an important pathway of availing food, alleviating poverty, and improving nutrition. In addition, reducing PHL has positive impacts on the environment and climate as it enhances farm-level productivity and reduces the utilization of production resources or expansion into fragile ecosystems to produce food that will be lost and not consumed.

Consumers with more disposable income at times purchase more than what they need and as a result waste edible food by simply throwing it away. Globally, one of the most wasted food products is vegetables (United Nations Environment Programme [UNEP], 2021). In the United States, fresh vegetables constituted 12% of the 19.4 million tonnes of retail-level food waste in 2020, while processed vegetables accounted for 5% (USDA, 2020). At the consumer level, approximately 39.7 million tonnes of food were wasted in the same year, with fresh and processed vegetables contributing 15% and 7%, respectively (USDA, 2020). Strikingly, food waste in high-income nations (estimated at 253 million tonnes annually) now rivals the total food production of sub-Saharan Africa (256 million tonnes) (FAO, 2019). These disparities underscore the critical need to address postharvest losses (PHL) as a viable strategy to reconcile imbalances between agricultural output and food accessibility, thereby enhancing global food security.

Qualitative losses are much more difficult to assess than quantitative losses. Losses in quality are evidenced by a decrease in the market value of the product (Munhuewyi, 2012). Any vegetable which is misshaped or has some blemishes may be as tasty and nutritious as one that is perfect in appearance. Sadly, such produce is only likely to have a market, only if the price is right (Munhuewyi, 2012). Qualitative losses reduces the quantity of a product that results due to the weight loss by factors such as an attack of insects, birds, rodents and moulds. It also occurs due to poor storage conditions or preservation methods (Kiaya, 2014). Thus, the reduction of quantitative losses is a higher priority than qualitative losses in developing countries.

2.2 African perspective

Postharvest losses (PHL) in Africa remain a critical barrier to food security and economic development, disproportionately affecting smallholder farmers who rely on agriculture for subsistence and income. Inefficiencies in storage, transportation, and processing infrastructure are primary contributors to these losses. For instance, Nigeria loses 40 to 50% of its annual tomato harvest due to inadequate cold storage facilities and poor road networks, translating to over $15 billion in economic losses (FAO, 2020). Similarly, Kenya experiences 20 to 30% postharvest losses in maize, valued at $90 million annually, largely due to improper drying techniques and pest infestations (World Bank, 2021). These losses not only undermine food availability but also deepen poverty cycles, as farmers lose income and struggle to reinvest in their livelihoods

2.3 Zambian perspective

In Zambia, smallholder farmers contribute about 80 percent of food production, but over 30 percent of the food produced by these farmers is lost because of post-harvest loss (Caritas Czech Republic in Zambia, 2020). Reducing food loss and waste, according to FAO (2016), is one of many steps required to ensure food security for a quickly expanding and urbanizing global population. According to the FAO, if storage technologies are brought into the farming community to support small-scale farmers, post-harvest losses in Zambia and Africa can be decreased. Produce would be preserved and post-harvest loses would be avoided with the aid of storage facilities like a cold room. It would also improve agricultural security and wealth creation, which will reduce levels of poverty among farmers and ultimately at the national level (FAO, 2016).

Similar to many developing nations, Zambia experiences food waste and loss at the beginning of the food value chain as a result of subpar/illogical harvesting methods, a lack of adequate infrastructure, and inadequate facilities for storage, cooling, and transport. As a result, up to 20% of harvests are lost annually (Zambrano et al., 2019). Poor harvesting techniques, a lack of or a lack of developed handling and processing techniques, and the market's failure to utilize the majority of the supply during the harvest season are some of the factors contributing to the high losses (Phiri, 2010). The nation now places a high priority on the need to increase food production. As populations increase, a greater need for sustenance is evident. However, a large portion of what is created never reaches the consumer, which worsens the nation's food insecurity. Loss of their produce reduces possible income, hinders access to nutrient-dense food, and worsens the food insecurity situation in the region.

2.4 Post-Harvest Losses in the vegetable value chain

The stages of PHLs in vegetable value chain includes harvesting, handling and packaging, transportation, storage, processing, and marketing. Each of these stages presents unique challenges that contribute to food losses. Understanding the causes of losses at each stage can help develop effective mitigation strategies to improve food security and economic returns for farmers and traders. According to the Food and Agriculture Organization (FAO, 2018), between 30 to 50% of fruits and vegetables are lost along the value chain, contributing to economic losses and food insecurity.

2.4.1 Losses at the Harvesting Stage

Harvesting is the first stage in the post-harvest value chain, and poor practices at this stage leads to significant losses. The two main challenges during harvesting are timing and mechanical damage. When crops are harvested too early, they may not have fully developed their flavor, texture, and nutrient composition, reducing their marketability and consumer acceptance (Buzby & Hyman, 2012). Conversely, delayed harvesting results in overripe produce, which becomes susceptible to fungal infections, insect damage, and rapid spoilage (Kader, 2013). In a study conducted in Kenya, Mbuk et al. (2011) found that improper harvesting techniques accounted up to 25% of losses in tomatoes and leafy vegetables.

Mechanical damage and Labor shortages also contribute to losses at this stage. According to James & Zikankuba (2017) in many rural areas, farmers rely on family labor, which may not always be available at peak harvesting times. This leads to delayed harvests and increased spoilage. Debela et al. (2011) found that in Uganda, labor shortages led to up to 18% of

vegetables being lost in the fields before they could be harvested. Additionally, mechanical damage contributes to PHLs due to rough handling, inappropriate harvesting tools, and unskilled labor. FAO (2014) reported that 20 to 30% of post-harvest vegetable losses in sub-Saharan Africa result from mechanical damage during harvesting. Hence, mechanization, such as hand-held harvesters, has been shown to reduce labor dependency and improve harvesting efficiency (Kitinoja & Kader, 2015).

2.4.2 Losses at Packaging stage

Poor handling practices cause mechanical injuries, bruising, and microbial contamination, leading to rapid spoilage (FAO, 2019). Handling and packaging determines how long fresh produce remains marketable and safe for consumption. Giordano et al. (2018) found that poor post-harvest handling results in 10 to 20% of fresh vegetable losses in Latin America. In Africa, many farmers lack access to proper packaging materials, leading to excessive spoilage before produce reaches markets (Negi & Anand, 2016). Packaging also influences post-harvest quality. According to Buzby et al (2009) traditional packaging methods, such as jute sacks and wooden crates, contribute to crushing, heat buildup, and contamination. In addition, a study in India found that ventilated plastic crates reduced tomato losses by 50% compared to traditional packaging methods (Negi & Anand, 2016). Hence the need for proper packaging materials.

2.4.3 Losses during Transportation stage

Transportation is a stage in the post-harvest value chain where significant losses occur due to poor road networks, improper loading practices, and lack of refrigerated transport. Many developing countries, including Zambia, rely on unimproved roads that cause excessive vibrations and mechanical damage to perishable produce such as tomatoes, cabbages, and leafy greens (Hodges et al., 2011). According to Sibomana et al. (2016), transportation-related losses in vegetables arise mainly from inadequate packaging, long transit times, and high temperatures. A study in Kenya revealed that over 15% of fresh vegetable losses occur during transportation, especially due to delays caused by traffic congestion and road conditions (Debela et al., 2011).

Overloading and improper stacking of vegetables in transport vehicles further exacerbate losses. Traders frequently pile vegetables in open trucks, sacks, or wooden crates, leading to excessive pressure and bruising (FAO, 2018). In many cases, vegetables are transported alongside non-food items, increasing the risk of cross-contamination and chemical exposure (Kader, 2013). A study in Uganda found that up to 30% of tomato losses resulted from improper

transport stacking methods, where lower layers of tomatoes were crushed by the weight of upper layers (Kitinoja & Kader, 2015).

2.4.4 Losses at the Marketing Stage

The final stage in the post-harvest value chain is marketing, where significant losses occur due to poor demand, inadequate storage conditions, and inefficient retail practices. Many traders in developing countries buy large quantities of vegetables to maximize sales, but poor market coordination results in oversupply and spoilage (Gustavsson et al., 2011). According to FAO (2021), 10 to 20% of vegetable losses in Africa occur at the market stage, mainly due to lack of proper storage facilities and exposure to extreme temperatures. In addition, overstocking exacerbates the problem. This is because vendors often purchase more produce than they can sell, leading to excess inventory that eventually spoils (Giordano et al., 2018). A study in Zambia's Soweto Market found that 38% of vegetable losses resulted from traders overstocking perishable produce without proper storage (ZDA, 2019). This is particularly problematic for highly perishable crops such as tomatoes, lettuce, and spinach, which require constant cooling and high turnover rates to remain fresh (James & Zikankuba, 2017).

Temperature exposure at markets is another significant issue. Many vendors sell produce in open-air stalls, where vegetables are exposed to direct sunlight accelerating dehydration and microbial growth (Waliyar et al., 2015). According to FAO (2019), vegetables stored in non-refrigerated conditions deteriorate twice as fast as those kept in proper storage. A study in Ghana's Agbogbloshie Market showed that traders lost up to 25% of their vegetables daily due to lack of shaded storage and cooling facilities (Bechoff et al., 2019). Implementing low-cost cooling technologies, such as evaporative cooling chambers and solar-powered cold storage, can significantly extend vegetable shelf life and reduce market losses. Therefore, Figure 1 shows post-harvest losses of vegetables at harvesting, packaging, and transportation and retail stages.

2.5 Conceptual framework

The conceptual framework (Figure 1) was designed by the researcher. The post-harvest food chain involves several stages where a crop is harvested from the field to the final stage where a product is transported to the retailer market. Food is lost or wasted throughout the supply chain from the harvesting stage down to household consumption. According to FAO (2011) during the whole phase of the post-harvesting chain, there is about 10 - 30% food loss that occurs in small scale production as well as large scale production. However, at each stage there are losses that take place.

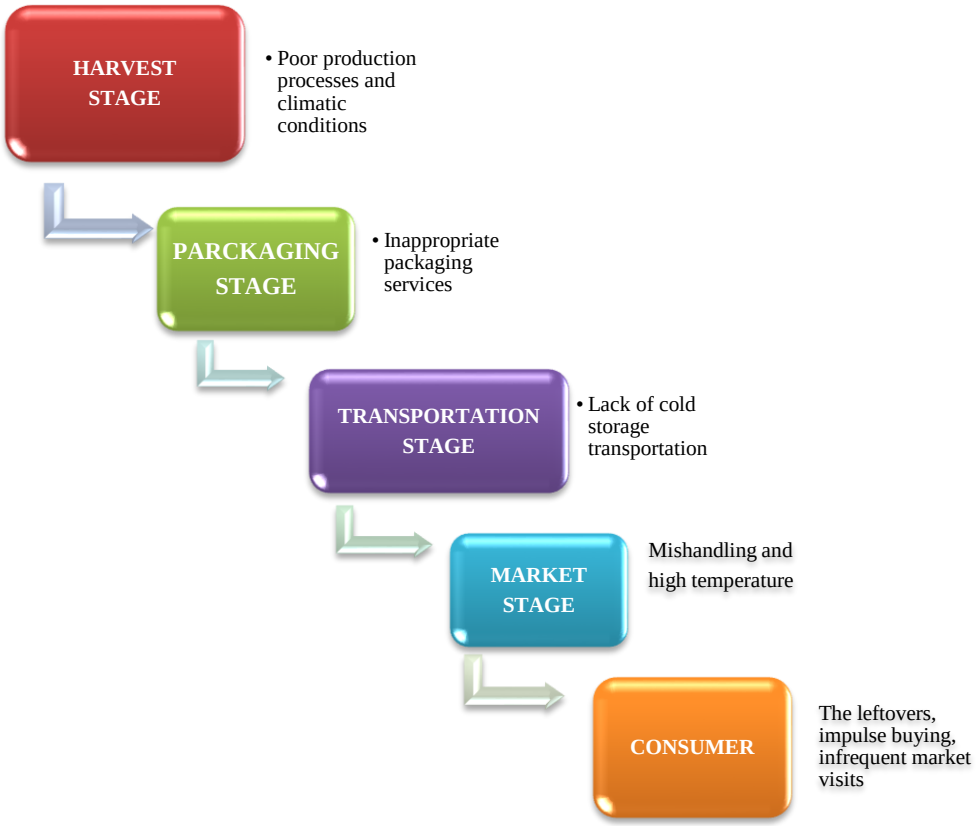

Figure 1: Stages of post-harvest losses

CHAPTER THREE

DESCRIPTION OF THE STUDY AREA

3.0 Introduction

This chapter discusses the location of Lusaka City Region on the map of Zambia, its climate, the inhabitants and agricultural activities. Lusaka City is the capital city of Zambia and the country's largest economic and commercial hub. The Lusaka City Region encompasses Lusaka and its surrounding districts, including Chongwe, Chilanga, Chisamba, Chibombo Kafue and Shibuyunji. This region is a major center for food production, trade, and distribution, particularly in the vegetable value chain. My study site is Soweto open market found in Lusaka city.

3.1 Location of the Study Area

Lusaka City is located in south-central Zambia, covering an area of approximately 360 km² (Central Statistical Office [CSO], 2022). It lies between latitude 15.3875° S and longitude 28.3228° E, at an altitude of 1,280 meters above sea level (JICA, 2019). The city is a key transport corridor, connected by Great North Road (T2) which links Lusaka to Tanzania and the Democratic Republic of Congo (DRC), Great East Road (T4) which connects Zambia to Malawi and Mozambique and Kafue Road (T1) which provides access to Zimbabwe and South Africa. These strategic connections make Lusaka a key trade and food distribution hub in Zambia.

3.2 Climate of Lusaka City Region

Lusaka City Food Region has a humid subtropical climate (Cwa in Köppen classification), with three distinct seasons which includes hot and dry season (August–November). Temperatures range from 20°C to 35°C (Zambia Meteorological Department [ZMD], 2020). The Rainy season (November–April). The region receives 800–1,000 mm of annual rainfall, mainly from the Intertropical Convergence Zone (ITCZ) (Mulenga et al., 2017). As well as the Cool and dry season (May–August). Temperatures drop to as low as 7°C at night, with daytime temperatures around 22°C. The rainy season is critical for agriculture, as it supports crop growth, while the dry season poses challenges due to water scarcity.

3.3 Population

Lusaka City has an estimated population of 3.3 million people (CSO, 2022), making it Zambia's most populous city. The Lusaka City Region, including surrounding districts, has a combined population of over 4 million. About 85% of the urban population live in urban or peri-urban areas and 15% of the rural population reside in farming communities in Chongwe, Chilanga, and Kafue. (UN-Habitat, 2020). Lusaka has an annual population growth rate of 4.9%, mainly due to rural-to-urban migration (CSO, 2022). The rapid population increase contributes to rising food demand and pressure on markets.

3.4 Socio-Economic Activities

Lusaka city is Zambia's economic center, with diverse activities that support livelihoods. The main socio-economic activities include agriculture (vegetable and maize farming), trade and commerce (wholesale and retail markets), manufacturing (food processing, textiles, cement, and metal fabrication), transport and logistics (trucking, courier services, and public transport), financial services (banking, microfinance, and insurance) as well as tourism and hospitality (hotels, lodges, and cultural sites). Over 60% of the workforce is engaged in the informal sector, such as street vending and market trade (ILO, 2020).

3.5 Agriculture

The Lusaka City Region plays a vital role in food production and urban food security. The major crops grown in the region are tomatoes, cabbages, onions, and leafy greens (FAO, 2018). Maize production is mainly grown in Chongwe, Chilanga, and Chisamba. Livestock farming includes poultry, dairy farming, and piggery are common. Irrigation farming is used to supplement rainfall, particularly along the Chongwe and Kafue Rivers (Phiri et al., 2019). Challenges include post-harvest losses, poor storage facilities, and price fluctuations in urban markets (Musebe et al., 2017).

3.6 Trade and Commerce

Lusaka city is Zambia's largest trading center, with a mix of formal and informal markets. According to ZDA (2019) major markets found in Lusaka includes Soweto Market, City Market and Kalingalinga Market are key distribution hubs for fresh produce. Supermarkets and Malls includes chain stores like Shoprite, Pick n Pay, and Choppies source vegetables from local farmers. Informal trade is mostly done by street vendors who play a major role in the food

supply chain, but face challenges such as market congestion and lack of storage (ILO, 2020). Hence, Lusaka's strategic location supports local and regional trade with South Africa, Tanzania, and DRC.

3.7 Transport and Logistics

Lusaka's food supply chain depends on road and rail networks, though poor infrastructure affects food distribution. Road Transport is the frequently used mode through the Great North Road, Great East Road, and Kafue Road which are the main routes for agricultural trade (JICA, 2019). The Tazara Railway is a form of Rail Transport that links Lusaka to Tanzania but is underutilized for food transport. It experiences lack of refrigerated transport which leads to post-harvest losses, especially for vegetables and dairy products (FAO, 2018). However, Poor road conditions in rural districts further increase transportation costs and food waste (Zambrano et al., 2019).

3.8 Justification for the selection of the study area

Lusaka City Region was selected as the study area due to its strategic importance as Zambia's largest urban market and agricultural supply hub, where districts such as Chongwe, Chilanga, Kafue, and Chisamba serve as primary sources of fresh vegetables. Despite its economic significance, the region faces major post-harvest losses due to inadequate cold storage, inefficient transportation systems, poor road networks, and limited access to modern preservation technologies, leading to significant food waste, economic losses for farmers, and market inefficiencies (Musebe et al., 2017). The major fresh produce markets, includes Soweto Market, City Market, and Kalingalinga Market, experience high levels of vegetable spoilage due to overstocking, poor hygiene conditions, lack of cooling facilities, and prolonged exposure to extreme temperatures (ZDA, 2019). Additionally, transportation challenges, including long travel distances, congestion, and reliance on non-refrigerated trucks, result in physical damage, bruising, and microbial contamination of vegetables before they reach consumers (Phiri et al., 2019). Hence addressing post-harvest losses in Lusaka is crucial, as it provides insights into supply chain inefficiencies, infrastructure gaps, and policy interventions needed to reduce food losses and enhance market efficiency. Given the high demand for vegetables, increasing urbanization, and government interest in reducing food insecurity, Lusaka is an ideal case study for understanding post-harvest challenges and developing strategies to improve food distribution, farmer incomes, and urban food security (FAO, 2021).

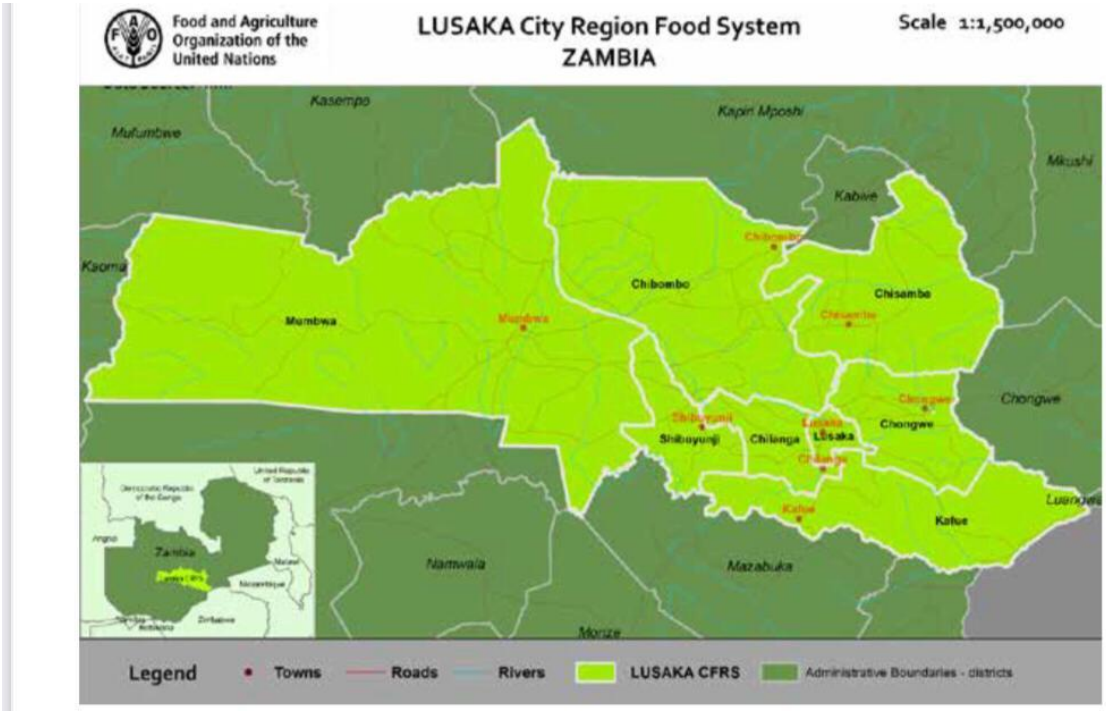

Figure 2: Lusaka City Food Region

Source: FAO and RUAF (2019)

CHAPTER FOUR

METHODOLOGY

4.0 Introduction

This section described the method that was used to undertake this study namely: study design, sampling, data sources and analysis. This research utilized both primary and secondary data to comprehensively analyze post-harvest losses in the vegetable value chain. The primary data was independently collected by the researcher, specifically focusing on the retail stage, where data was gathered on handling losses at the retail stage and the coping mechanisms employed by vendors at Soweto market. All data collection, analysis, and interpretation related to the retail stage were conducted solely by the researcher, ensuring an independent assessment of the challenges faced by traders.

In addition to primary data, secondary data was obtained from the Africities Food Project that was based on household surveys, a larger study examining food systems in urban markets. The researcher was also part of the data collection team for this project, contributing to gathering information on PHLs of the value chain. The secondary data provided insights into quantitative estimates of post-harvest losses at various nodes in the supply chain and the underlying causes of these losses. However, while this data served as a reference, the researcher independently analyzed and interpreted all findings, ensuring that the study maintained its originality and contributed unique insights into post-harvest loss management.

This study focuses on commonly traded leafy vegetables in Lusaka's open markets, includes cabbage, rape, spinach, chinese cabbage, and chibwabwa (pumpkin leaves). While tomatoes are botanically classified as fruits, they are widely treated as vegetables in market systems due to their culinary use and trade categorization. Hence, tomatoes are also considered as vegetables in this study.

4.1 Philosophical perspective

This research adopts a critical realist ontological position, which acknowledges that an objective reality exists but is shaped by social, economic, and environmental factors. In the context of post-harvest losses, vegetables physically deteriorate due to factors such as poor storage, inefficient transportation, and inadequate market infrastructure. However, traders' perceptions, experiences, and decision-making processes also influence how these losses occur and how they are managed. The study follows an interpretivist epistemological approach,

which emphasizes understanding human behavior, experiences, and perspectives in a given social context. Since post-harvest losses are influenced by human actions, decision-making, and socio-economic conditions, an interpretivist stance allows for an in-depth exploration of traders' knowledge, strategies, and challenges in minimizing losses.

4.2 Study Design

This research employed an instrumental case study design to gain a comprehensive understanding of post-harvest losses within the vegetable value chain, with Lusaka serving as the focal case. An instrumental case study utilizes a specific case to provide insights into a broader issue or phenomenon, where the case itself is of secondary interest but instrumental in refining a theory or understanding a larger context (Hyett et al., 2014). By conducting an in-depth examination of Lusaka's vegetable markets, the study aimed to elucidate factors contributing to post-harvest losses, thereby offering valuable insights applicable to similar urban markets facing comparable challenges.

4.3 Study Population

The study was carried out in the seven districts of Lusaka city food region namely Lusaka, Chongwe, Chisamba, Chibombo, Chilanga Kafue and Shibuyunji. The study targeted vegetable farmers and retailers in Lusaka city region who were willing to participate in the study.

4.4 Sampling Technique

This study utilized a combination of random sampling and purposive sampling to ensure a representative and comprehensive analysis of post-harvest losses in the vegetable value chain. The Africities Food Project (2023) surveyed a total sample of 2,000 respondents across multiple districts. For this study, a sub sample of 1,000 respondents was selected from the original Africities dataset. The selection process was conducted using random sampling, ensuring that respondents were equally represented from each district to maintain geographical balance and minimize selection bias. In addition, purposive sampling was employed to select 30 key informants for primary data collection. This approach was used to target individuals with specialized knowledge and direct involvement in the vegetable value chain. The sample included 2 council representatives, 3 market representatives, 5 middlemen, 10 retailers and 10 farmers from Soweto open market. The use of mixed method sampling technique provided quantitative measurable evidence from the Africities Food Project survey while qualitative data

offered in depth insights from key informants, thereby enhancing the validity and reliability of the findings.

4.5 Data Sources

In this study, the secondary data from Africities Food Project collected using questionnaires were used to gather quantitative data on the volume of vegetables handled at various stages in Lusaka city region. The questionnaires were used to collect data on the causes of PHL, evaluate the value chain for the vegetables and to quantify the losses. The primary data was collected independently through the use of semi-structured interview guide administered to key informants at Soweto market. The key informants include farmers, retailers, middlemen, representatives from the market and council. The interview questions for all groups were focused on the handling of losses and ways of reducing the losses through different coping mechanisms. Furthermore, key informants were asked questions regarding the market about their vegetable practices such as handling, packaging, transport and storage. This mixed method approach ensured a comprehensive understanding of post-harvest losses.

4.6 Data Analysis

Both quantitative and qualitative data analysis techniques were employed to comprehensively assess post-harvest losses (PHL) across the vegetable value chain. Quantitative data were analysed using descriptive statistics in Minitab Software version 18, where frequencies and percentages summarized socio-demographic profiles and post-harvest handling activities. Information on PHL at different stages from harvesting, packaging, transportation, and retail stage was gathered from farmers and intermediaries with total losses estimated by summing losses at each value chain node. Qualitative data from key informant interviews were analysed using thematic analysis, where interview transcripts were coded to identify recurring themes, including storage challenges, transportation inefficiencies, and coping strategies. These themes were compared across value chain actors to assess variations in experiences. To ensure reliability, qualitative findings were triangulated with quantitative results, and direct quotes from respondents were incorporated to provide contextual depth. This mixed-methods approach strengthened the study by integrating statistical trends with real-world insights.

4.7 Ethical Consideration

Ethical clearance of this study was obtained from the University of Zambia (UNZA). In addition to this, Permission was obtained from the Lusaka City Council (LCC) to carry out the research based on vegetable PHL involving market farmers, middlemen and retailers. Consent was obtained from participants because the study used both primary and secondary data. Further, to protect the privacy of participants, their names were not recorded in the research.

CHAPTER FIVE

PRESENTATION OF FINDINGS

5.0 Introduction

This chapter presents the study findings. The presentation has been done based on objectives. It proceeds with a description of the demographic characteristics of the study area. The first subsection explains the quantity of PHL that takes place in each district as well the causes of PHL. The second subsection shows the copying mechanisms of PHL.

5.1 Demographic Representation of respondents

The results show that more than half (61%) of the respondents in this region were male while the remaining 39% were female.

The Figure 3 shows the participation percentage of respondents of each district in the region. Chongwe has the highest percentage, followed by Lusaka, Chibombo, Chilanga, Kafue, Chisamba and Shibuyunji with the lowest participation percentage.

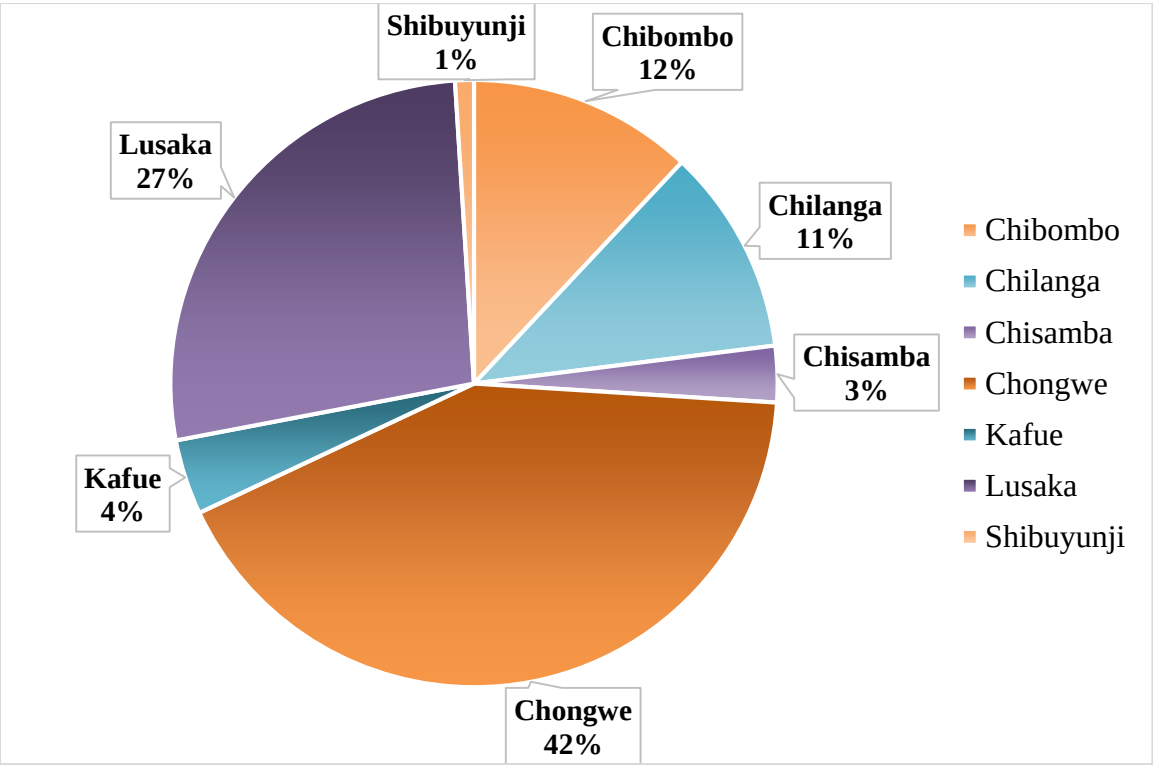

Figure 3: ***Participation percentage of respondents of each district in Lusaka region.***

Source: Africities Food Project (2023)

5.2 Estimation of Post-Harvest Losses of Vegetables on the Value Chain

5.2.1 Quantity Losses at Various Nodes of the Vegetable Value Chain

The quantity of losses that take place in both tomatoes and fresh vegetables from the time of harvest to the market stage are shown in figure 4. This shows the stages of both tomatoes and fresh vegetables through produce, packaged, transported, arrived at the market and what was sold.

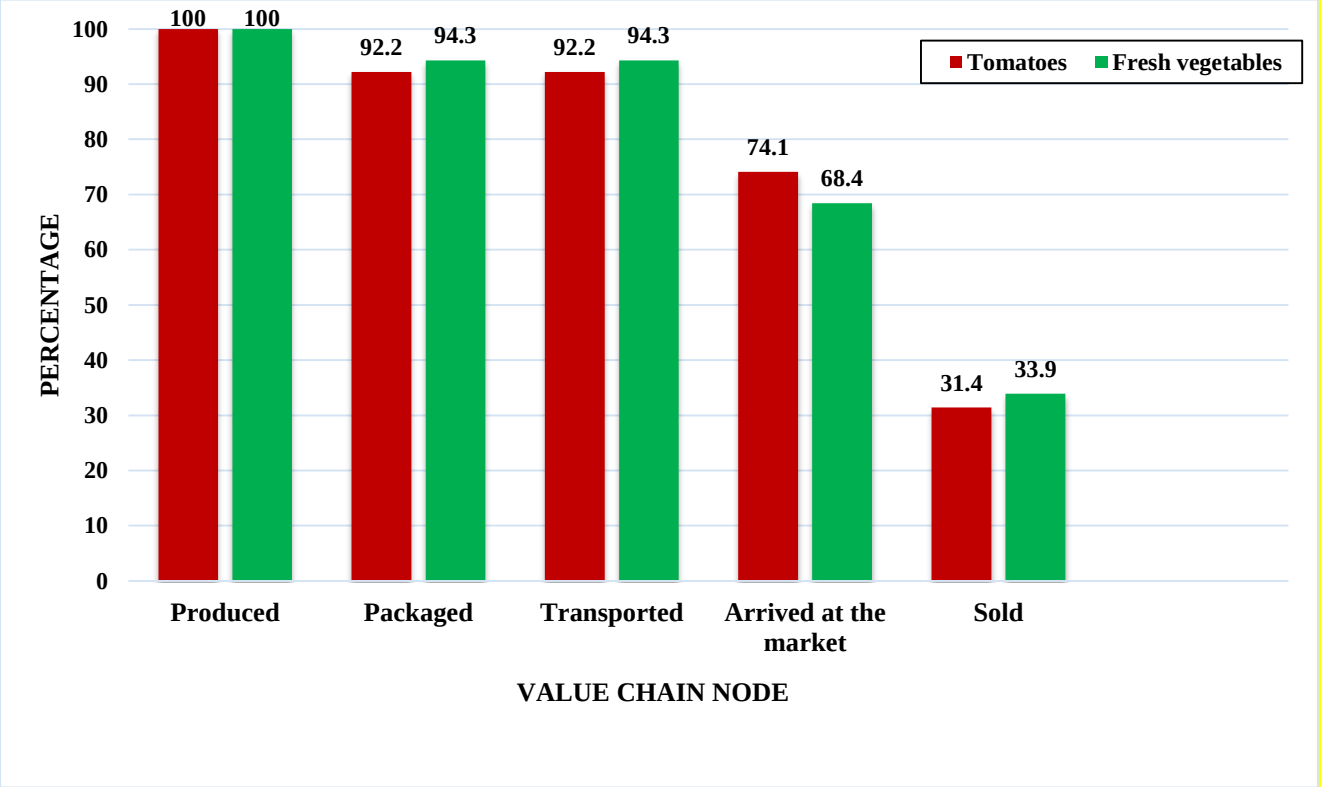

*Figure 4**: Quantity losses at various nodes of the vegetable value chain.***

Source: Africities Food Project (2023).

The table 1 shows the losses that took place at each stage of value chain, highlighting the percentage losses for tomatoes and fresh vegetables.

Table 1: Estimation of quantity losses at various nodes of the vegetable value chain.

STAGES	TOMATOES (%)	LOSSES (%)	FRESH VEGETABLES (%)	LOSSES (%)
Produced - Packaged	100 – 92.2	7.8	100 – 94.3	5.7
Packaged – Transported	92.2 – 92.2	0	94.3 – 94.3	0
Transported – Arrived at the market	92.2 – 74.1	18.1	94.3 – 68.4	25.9

Arrived at the market - Sold	74.1 – 31.4	42.7	68.4 – 33.9	34.5
TOTAL LOSSES		**68.6%**		**66.1%**

Source: Africities Food Project (2023)

Focus group discussion (FGD) and key informant interview indicate that vegetable harvesting, and packaging practices are improper that they do not give attention to loss rather to harvest and take to home and market for selling. Furthermore, the discussion highlighted that the absence of adequate infrastructure has led to the adoption of these substandard practices.

It was also observed and discussed during FGD that the respondents had poor transportation practices that could induce the loss of vegetables especially tomatoes due to mechanical/physical damage and overheating (natural breakdown, decay and increase the rate of water loss). Also, it was observed that most of the respondents transported vegetables on the poor roads without a suitable package at a mean distance of 11.5 Km that might also lead to loss of vegetables.

A middleman from Soweto market who buys the tomatoes and vegetables directly from Shibuyunji farms in an interview on 10th September, 2023 revealed that:

> *Transportation is a major contributing factor to the post-harvest losses (PHL) of vegetables and tomatoes. The condition of the gravel roads we use to transport our goods to the market plays a significant role as these rough roads can cause bruising and crushing of the produce during transit, leading to considerable losses. The bumpy and uneven surface of gravel roads subjects the vegetables and tomatoes to constant jostling and impact, especially when transported over long distances. This physical stress results in damage to the delicate skin of the produce, making them more susceptible to spoilage and decay. Furthermore, the lack of proper infrastructure, such as refrigerated trucks or suitable packaging materials, exacerbates the problem. Without adequate protection and temperature control during transportation, the quality of the vegetables and tomatoes deteriorates rapidly, further increasing the likelihood of post-harvest losses.*

5.2.2 Percentage Loss of Tomatoes and Vegetables per District

The figure 5 shows the loss of tomatoes and fresh vegetables for each district in Lusaka region. The district with the most losses of tomatoes was Kafue followed by Shibuyunji, Chongwe, Chilanga, Lusaka, Chisamba and Chibombo with the least losses. On the other hand, the district with the most losses of fresh vegetables were Chongwe followed by Lusaka, Chilanga, Chibombo, and Kafue, while Shibuyunji and Chisamba had the least losses.

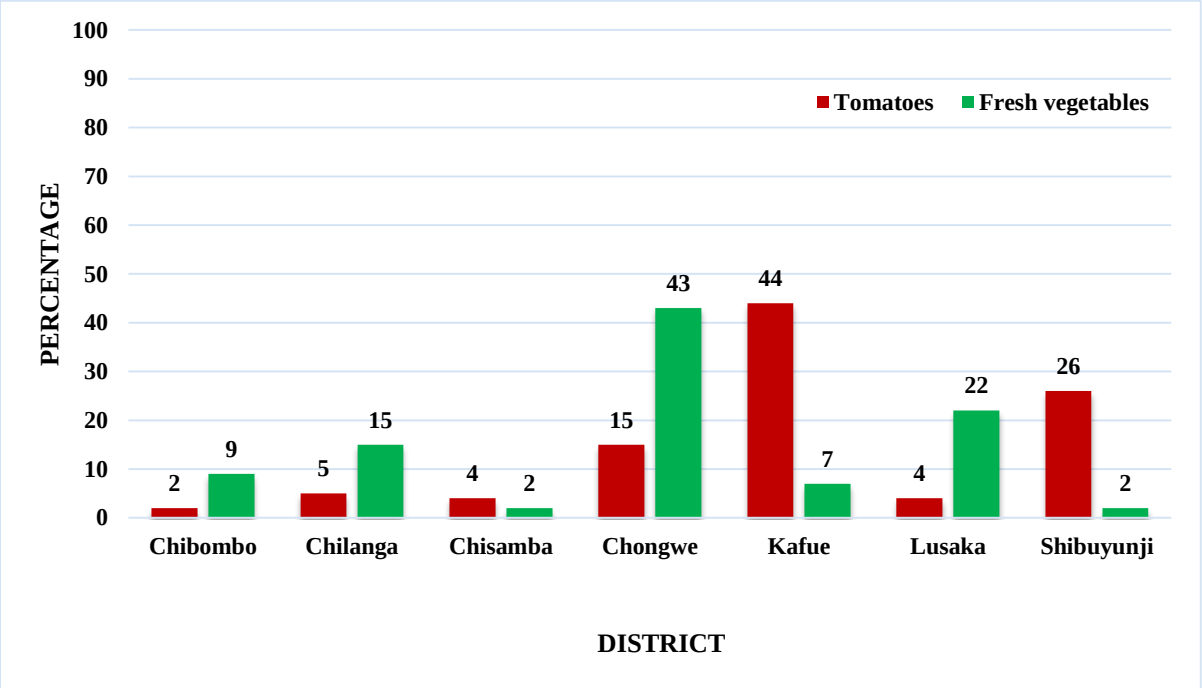

Figure 5: ***Percentage loss of tomatoes and fresh vegetables in each district.***

Source: Africities Food Project (2023)

5.3 Main Causes of Post-Harvest Losses

The common causes of PHL in Lusaka region according to figure 6 were mishandling, high temperatures, lack of storage facilities, and pests/disease attack. Other causes of PHL included price fluctuation, maturity of produce, theft (act of stealing vegetables from farms or markets or other locations without the owner's consent), transport challenges, bad weather, and lack of proper methods of preservation.

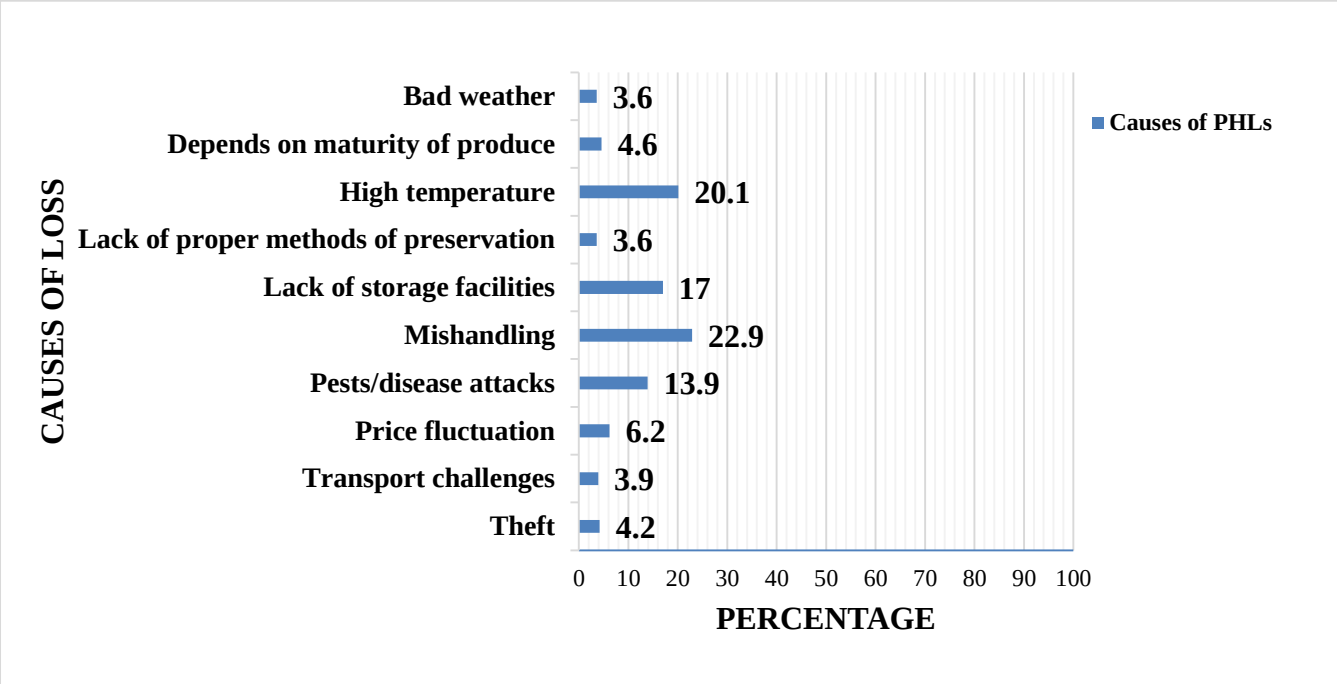

*Figure 6**: Main Causes of Post-Harvest Losses**.*

Source: Africities Food Project (2023)

A retailer from Soweto Market in an interview on the 22nd September, 2023, narrated that:

> *As a retailer who sells vegetables and tomatoes, high temperatures pose a significant challenge for me. The intense heat fastens the ripening process of these perishable goods, which means I must be vigilant in monitoring inventory and ensuring that items are sold promptly to avoid spoilage. Additionally, the heat can make it uncomfortable for customers to buy the tomatoes and the vegetables as they tend to shrink quite fast, potentially reducing foot traffic and sales.*

Another key informant from Soweto Market in an interview on the 22nd September, 2023, narrated that:

> *Bad weather contributes to the PHL of vegetables and tomatoes. Heavy rains causes extensive damage to the crops, leading to reduced yields and lower-quality produce. Floods pose a severe threat, inundating fields and causing soil erosion, ultimately washing away entire crops. As a result, such events leaves farmers grappling with substantial losses and challenges in salvaging what remains. In addition, extreme weather events disrupt transportation and supply chains, exacerbating the situation for retailers. Delays in delivery and difficulties in obtaining fresh produce lead to shortages and potential stockouts. The scarcity of vegetables and tomatoes, coupled with increased demand, inevitably drives prices higher. This not only affects retailers' profitability but also impacts consumers, who may face limited options and inflated prices.*

There are various examples of processes contributing to PHL according to Table 2 from handling at harvesting to packaging, storage through transportation and final delivery to the market.

Table 2: Processes contributing to PHLs at different stages.

Stage	**Examples of processes contributing to losses**
Handling at harvesting	Vegetable damaged during harvesting by not using appropriate tools for harvesting.
Packaging	Inappropriate packaging damages produces such as overloading leading to squeezing the vegetables when packing.
Storage	Not using appropriate storage equipment's for example clean boxes or sacks.
Transportation	Losses due to inadequate transport infrastructure resulting in spoilage or bruising.
Market	Rough handling of produce, failure to maintain appropriate temperature, improper refrigeration facilities leading to increased losses.

Source: Field Data (2023)

During the FGD participants revealed that there was no training regarding the post-harvest management practices given by anybody and even the respondents are unfamiliar with post-harvest handling issues. The key informant interviews revealed that while certain pre-harvest practices are implemented in the study area, there is a notable absence of post-harvest management experts to provide training and awareness to the respondents. This gap hinders efforts to reduce and control post-harvest losses (PHL) of their fresh produce.

5.3.1 Handling of Losses at Retail Stage

The figure 7 shows the ways in which the losses of tomatoes and fresh vegetables are handled at the retail stage by the farmers, middlemen and retailers. Most of the respondents stated that they dispose-off all the losses while others do nothing. Some respondents stated that they sell the vegetables cheaply, give away, resupply to animals, consume, use as manure and very few respondents preserve.

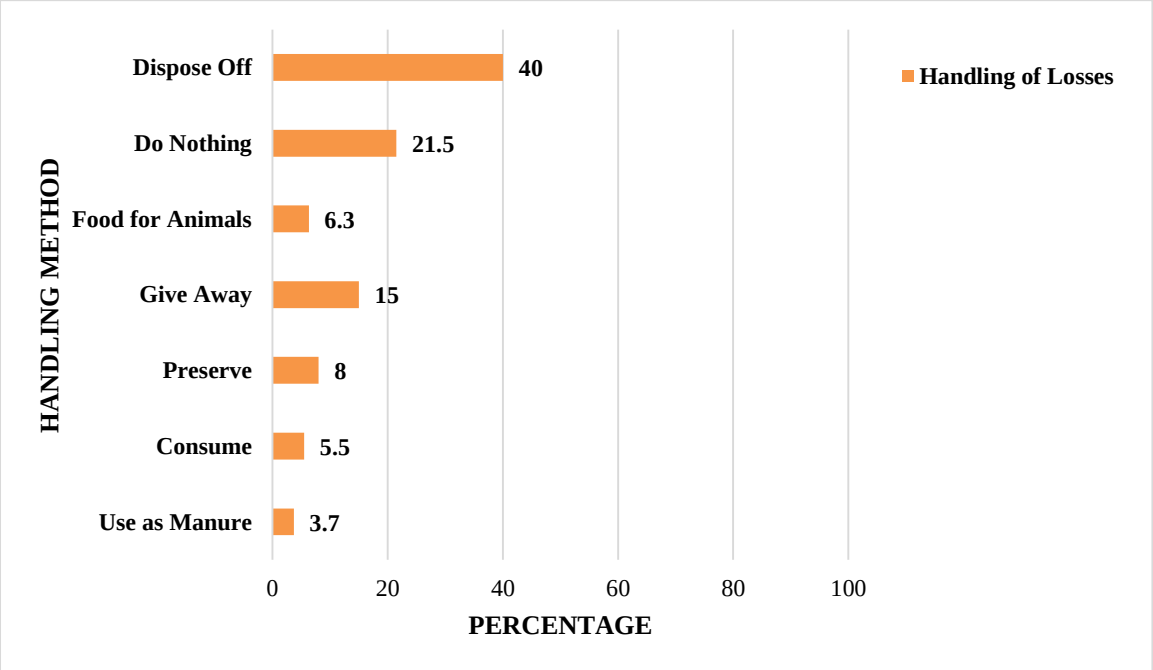

Figure 7: ***Handling of losses at retail stage.***

Source: Field Data (2023)

A farmer from Soweto Market in an interview on the 21st October, 2023, narrated in Chewa that:

> *Ngati masamba anga Sanagulidwe, ndimabwelera nao kunyuma kuopa kuonongeka. Timapeza njila zambiri mowasewenzetsela, mwa ena amasamba, amakhala cakudwa ca banja pakuonetsesa kuti asaonongeke komanso kutipasa cakudwa cothandiza thupi.*

Mwakuonjezela, ena okhalila masamba timagawila ziweto zathu maka-maka nkhumba cifukwa zimakonda masamba. Ndinjila imodzi yacisamalilo imene ingacepese zokhalila ndi kukhalanso zaphindu mu mabanja athu komanso ziweto. Nthawi zina timasamalila masamba pakuumika. Masamba monga rape, chinise, khabichi ndi thelere zimasamalilidwa paku umika maka- maka nthawi ya malanga momwe zingaume posacedwa. Njila iyi yacisamalilo ima onjezelako nthawi yakukhala kwa masamba komanso kuyamvelanso bwino ngakhale nyengo yake itatha.

Translated;

When my vegetables do not sell, I take them back home to avoid wasting them. We find various ways to make use of them. Some of the vegetables become meals for my family, ensuring that they are not wasted and providing us with nutritious food. Additionally, we share some of the leftover vegetables with our animals, especially pigs, since they love leafy vegetables like spinach. It is a sustainable approach that reduces waste and benefits both our family and our animals. At times, we also preserve the vegetables by drying them. Vegetables like rape, Chinese, cabbage, and okra are suitable for drying, especially during the dry season when they can quickly dry out. This preservation method allows us to extend the shelf life of the vegetables and enjoy them even when they are out of season.

5.4 Coping Mechanisms

Based on findings from the Africities food project, Table 3 highlights practical coping mechanisms adopted across the three stages of the vegetable value chain to reduce post-harvest losses (PHL) and enhance resilience. These strategies are ranging from harvest timing adjustments to resource pooling in transport to address critical points identified in the vegetable value chain aligning with broader efforts to improve food security and supply chain efficiency.

Table 3: Shows the coping mechanisms along the value chain

VALUE CHAIN STAGE	COPING MECHANISMS
Harvesting stage	• Harvest Timing • Use of shaded areas or temporary sheds before transportation.
Packaging stage	• Sorting and grading • Use of ventilated packaging

	• Appropriate packaging materials • Standardize packaging sizes
Transportation stage	• Covering produce with sacks or plastic sheets to reduce sun exposure. • Loading produce fewer times to prevent bruising. • Pooling Transport Resources

Africities Food Project (2023)

5.4.1 Coping Mechanisms to Reduce Post-Harvest Losses at Retail Stage

The figure 8 shows the coping mechanisms used at the retail stage to prevent having more losses of vegetables. Most of the respondents said it is by keeping the produce cool to avoid damage by the sun. The other coping mechanisms included separate the injured, diseased or decayed produce from the fine produce, proper clean storage, avoid injury at all costs, and assess maturity and quality of produce immediately the produce arrives the market and drying.

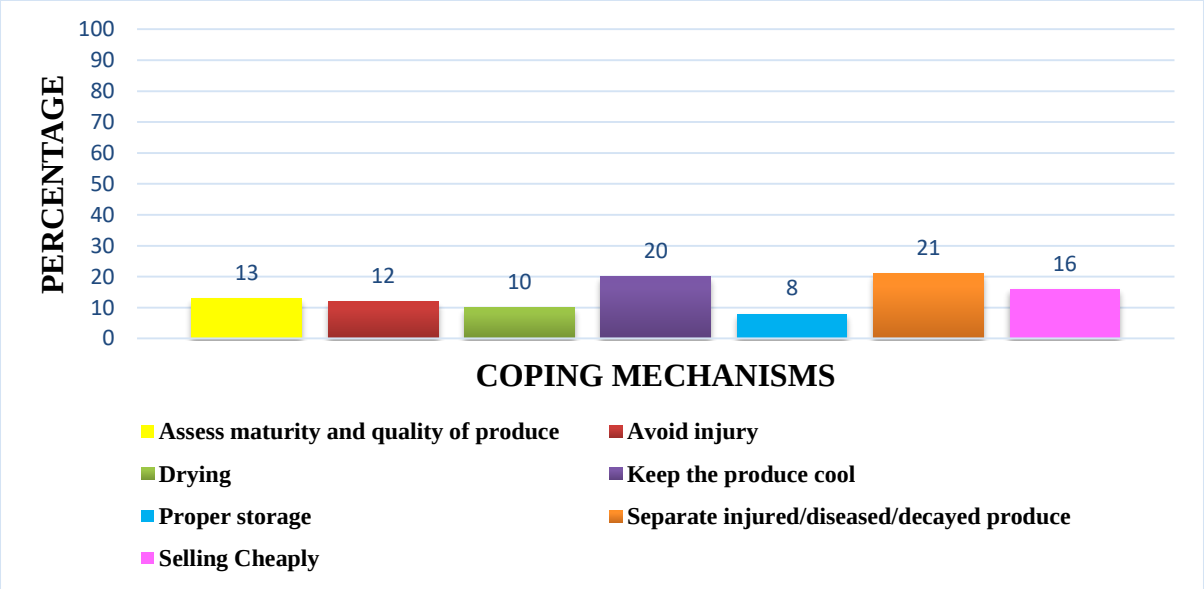

*Figure 8**: Coping mechanisms to reduce post-harvest losses at retail stage.***

Source: Field Data (2023)

A key Informant from Soweto Market in an interview on the 16th June, 2023, narrated that:

> *The post-harvest losses are the biggest challenge in the market as they experience a lot of losses during the produce harvest at on peak period of the year. In the previous years they used to sell in bulk to supermarkets but not anymore. They also used to work with a certain company that used to make tomato sauce but at the moment the company is no longer operational. Hence, they usually have losses as they are not working with any stakeholders other than exporting once in a while to Chipata and Zimbabwe. Therefore, they try by all means to avoid the losses through assessing the maturity and quality of produce by gradually reducing the prices as it stays on the market for a longer period of time.*

Further, a key informant from Lusaka City Council in an interview on the 06th of July, 2023, narrated that:

> *The council is in charge of garbage and waste collection in the market and the vegetables are one of the major causes of waste in the New Soweto City market. This is because vegetables are perishables and everyday there are losses that take place. These losses are higher during the on peak period as they collect more vegetables losses compared to the off peak period. In the past, they used to have a cold room where vegetable owners would keep their produce at a fee but now that cold room is no longer operational. Hence, this has resulted to more losses of the vegetables.*

In summary, the causes of food losses are mainly connected to financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult climatic conditions, infrastructure, packaging and marketing systems. At retail stage, it was observed that some retailers sell part of their vegetable consignments to household consumers in a cut form, packed in bags of different sizes. This in turn results into wastes due to over-processing since not all customers need vegetables in that form, hence high PHL.

CHAPTER SIX

DISCUSSION OF FINDINGS AND CONCLUSIONS

6.0 Introduction

This study investigated the estimation of PHL on vegetable value chain in Lusaka open market. This chapter provides a discussion of findings which are in line with main themes of this research. The chapter also provides conclusions and recommendations from the findings presented.

6.1 Discussion of Findings

6.1.1 Participants Information

The study found that majority (61%) of the respondents were male compared to 39% of the respondents who were female. This shows that males in this study were mostly involved in vegetable crop production. This finding is comparable to a study by Fakayode et al. (2012) who stated that about 71% of vegetable farmers were males while few (29.3%) were female. Another similar finding was reported by Reta (2020) who reported that 82.5% of farmers were males while 17.5% were females. This implies that farming is mainly undertaken by males than females because in the study area generally most of the men are engaged in farming activities than women who prefer more white-collar jobs. Similarly, Kidane (2016) found gender disparity in the involvement of households headed in Armachio district, Amhara region, Ethiopia. The study finds overwhelming percentages of male respondents while fewer percentages were female headed.

6.1.2 Estimation of PHL of Vegetables on the Value Chain

6.1.2.1 Quantity Losses at Various Nodes of the Vegetable Value Chain

This section discusses the quantity of losses incurred on vegetables from the time of harvest to the market stage.

The total loss of tomatoes was 68.6% while fresh vegetables was 66.1% with a mean percentage loss of 67.4%. Quantitative analysis of vegetable losses across the value chain demonstrated significant losses at every stage, with retail-level losses being particularly severe. As shown in Table 1, tomatoes experienced 42.7% losses at retail, while vegetables showed 34.5% losses. These figures align closely with the Africities Food project's city wide estimates of 30-35% for

similar crops (Africities Food Project, 2023), suggesting that Soweto Market's losses are representative of broader Lusaka trends. Hence, PHL is significant at all the stages.

6.1.2.1.1 PHL of fresh vegetables and tomatoes during packaging

According to Table 1 which presents a breakdown of PHLs across different stages of the vegetable value chain. The study revealed that 100% of tomatoes and 100% of fresh vegetables produced experienced losses during packaging. Specifically, 7.8% of tomatoes and 5.7% of fresh vegetables were lost, resulting in an average packaging loss of 6.8% for vegetables. This finding is in disagreement with a study by Reta (2020) who only reported that 2.1% loss of head cabbage was incurred because of poor holding materials during packaging. Similarly, Negi and Anand (2016) enlighten that in the case of produce packed in jute bags, usually stacked on each other that cause the limitation of ventilation, which usually results in produce rot due to high level of physiological activities of the produce. Again, similarly Yahaya and Mardiyya (2019) stated that all the packages must be ventilated to prevent the physiological break- down of the products. The possible reason for this loss during packaging can be attributed to improper practices that do not give attention to loss rather to harvest, take home and market for selling. In addition, it is also these practices which may be caused due to lack of infrastructure lead to such poor practices.

6.1.2.1.2 PHL of fresh vegetables and tomatoes during transportation stage

In this study, although 92.2% of tomatoes and 94.3% of fresh vegetables were properly packaged for transportation, significant losses still occurred about 18.1% in tomatoes and 25.9% in fresh vegetables, resulting in an average transportation loss of 22%. These findings are notably higher than those reported in similar studies. For instance, Reta (2020) recorded a much lower transportation loss of only 2.6% in head cabbage. Seid et al. (2013) also reported a 2.8% loss due to poor transport systems. In a related study, Yeshiwas and Tadele (2021) found that the maximum post-harvest losses during transportation reached 10% for both pepper and tomato, which is still lower than the losses observed in this study. According to Sirivatanapa (2006), the highest losses in horticultural crops typically occur during marketing, transportation, and storage stages and sometimes extending throughout the entire value chain. This is largely because fresh produce continues to undergo metabolic processes such as transpiration and respiration after harvest, leading to deterioration once stored food and water are depleted.

According to Table 2 which shows the examples of processes contributing to PHL, inadequate transport infrastructure contributes to PHL. The study found that poor road networks, lack of refrigerated transport, and long travel distances were the main contributors to these losses. The Africities Food Project (2023) similarly highlighted the role of inadequate transport infrastructure in accelerating spoilage, especially for perishable produce. As shown in Figure 3, most vegetables are transported in open trucks without temperature control, exposing them to heat and physical damage during transit. Farmers and traders reported that bumpy roads often lead to bruising and crushing of vegetables, reducing their market value upon arrival. Given that most smallholder farmers lack access to refrigerated storage and cold-chain logistics, transportation losses remain a major barrier to improving food security and economic sustainability.

6.1.2.1.3 PHL of fresh vegetables and tomatoes at retailers' level

Losses at the retail stage are more expensive and had greater environmental impact because of all the value addition costs for packaging, transport and storage accrued along the chain (Buzby et al., et al., 2009). In this study according to Table 1, it was observed that out of the 74.1% tomatoes and 68.4% fresh vegetables that reached the market place, only 31.4% of the tomatoes and 33.9% of fresh vegetables were sold. This shows that there was a 42.7% loss in tomatoes and 34.5% loss in fresh vegetables incurred during retail with an average loss in 38.6% in vegetables during retail. Reta (2020) reported a mean total percentage loss of head cabbage at retailers' level of 18%. The loss of vegetables caused due to poor marketing systems such as selling in direct sunlight (no shelters, poor trimming practices and mixing marketing with other commodities. Similarly, Kitinoja (2013) explained that at least 28% of the total cabbage production is lost at the retail level due to rough handling of head cabbage heads during transit and poor storage conditions. A similar study of Gonzales and Acedo (2016) also reported that 16.1% of a total loss of head cabbage was incurred at the retail stage after three days holding at ambient temperature in the traditional chain in Cebu, the Philippines as a result of improper handling of fresh produce and poor packaging during transportation.

Similar findings were also reported by Mtui (2017) who observed that retail markets recorded higher vegetables PHL in which 47.5% of African Eggplant, 12% of amaranth and 35.2% for tomatoes were lost. Such losses can be attributed to poor handling practices from farm gate to retail level. The reported high PHL could be because they are easily noticeable by farmers, traders and consumers. A study conducted in the UK by Garnett, (2006) estimates postharvest

fruit and vegetable losses in UK to be around 25% with the highest losses occurring at the supermarket level due to "quality out grades" of produce that does not meet certain cosmetic standards.

Retailers are often faced with the challenge of implementing an increase in price mark ups for fresh produce as they too need to generate reasonable profit to sustain their operating systems from whatever volumes remain after factoring in the losses. In the end not many people will be able to have access to a vegetable rich diet simply because of the cost (Hodges et al., 2011). Weinberger et al. (2008) was able to show how the volume and value of PHL varies across the supply chains actors for three Asian countries with similar supply chains. They revealed that with regards to total volume of physical losses experienced along the distribution chain it is the farmer who is most affected (41%) while the retailer experiences the highest share of economic loss of almost 38%. Therefore, while losses at the collection and wholesale centres are important, it is at the start and end sections of the chain where the issue of postharvest vegetable losses is more critical for this particular case study. The quantity loss of the selected vegetables at each stage of the supply chain is relatively high compared to what is produced and marketed; therefore, these losses cannot be overlooked.

6.1.3 Main Causes of PHL

The losses were attributed to different factors such as mishandling (22.9%), high temperatures (20.1%), lack of proper storage facilities (17%), and poor pests/disease control (13.9%). In case of crop mishandling, most farmers in this study experience a lot of losses due to mishandling as most workers have not been trained on the correct handling of vegetables when plucking from the stalk and others through squeezing and over pulling of tomatoes when picking them from the plants as this makes tomatoes to get cracked or smashed. This finding is not so much different from the study conducted by Mbuk et al. (2011) who stated that mechanically damaged fresh vegetables are unsightly and symptoms include bruises, cuts, cracks and punctures which in turn facilitate decay and enhanced water loss results into vegetable losses. In addition, Mbuk et al. (2011) established that careless handling during loading and off-loading of tomatoes, contributed to breakages (18%) and the undesirable softening to another 34% of the whole consignment. He further added that tomato packages were often squeezed into vehicles preventing good ventilation and as a result over 50% of the consignment was lost (Mbuk et al., 2011). Hence, fresh vegetables and tomatoes are quick perishables and if care is not taken in handling, they soon decay and become unfit for human consumption.

Ruta (2020) observed that the respondents used different methods of head cabbage harvesting practice so that 60.8% of them used pulling with hand while 39.2% of them used twisting and cutting with a machete. It was observed that during those harvesting practices, the produce was subjected to force that could lead to the mechanical and physical loss of head cabbage. Therefore, the extent of PHL of head cabbage at harvesting level was 4.2%. Therefore, during harvesting the head cabbage should not be snapped or twisted, as this method damages the head and results in inconsistent stalk length and trim since broken stalks are also more susceptible to decay (Acedo, 2010). Garikai (2014) also stated that training farmers' aids in proper postharvest handling practices and technologies would assist in improving postharvest handling efficiency and formal postharvest handling training would experience lower PHL compared to the untrained farmers.

In the case of high temperatures, this study found that high temperature led to shrinking, and yellowing of the vegetables, drying up of harvested vegetables as they begin to lose water immediately after they are detached from the plant. When it is too hot, the high temperature (above 25 Degrees Celsius) affects the tomatoes they become soft and damage easily. Damages also happen due to breakages and exposure of produce to direct sunlight which leads to losses. Similarly, Ruta (2020) observed that majority of respondents harvest cabbage in the afternoon that the product being exposed to the heat of the sun which induces weight loss and wilting. In agreement also, Bekele (2018) discussed that harvesting time affects the quality of fresh produce and it is desirable to harvest fresh produces during the cooler parts of the day such as in the early morning and in the evening just after sunsets to reduce the risk of heat injury and sunburn. Similarly, Garikai (2014) recommended that PHL of spinach will be diminished significantly if it is harvested in the morning instead of the afternoon. Furthermore, Kereth et al. (2013) reported that harvesting activities should be completed during the coolest time of the day, because of high temperatures and evaporation which causes the vegetables to shrink, thus affecting the marketing quality.

Storage Facilities and pest control are elemental parts in the post-harvest value chain. Lusaka city region experiences inadequate storage facilities. This is because farmers shy off from handling and storing their vegetables in appropriate conditions and facilities due to the high-cost implications associated with proper storage. Pests like rats and insects damage the produce either in the field or in the storage place for instance, once cabbage has been infected with the pests whilst it was in the field, when harvested it tends to have holes on the leaves and no longer looks appealing . These results are in line with Musebe et al. (2017) who estimated that about

31% of vegetables are lost and such losses are caused by pest and diseases, inadequate sorting or grading, rough handling, lack of cooled storage facilities and lack of adequate packing material. This is also in line with the findings of Adepoju (2014) who concluded that lack of storage facilities, poor transport networks and long distances to the markets magnified tomato PHL faced by farmers in Osun State, Nigeria.

However, Debela et al. (2011) reported that PHL of horticultural commodities around the Jimma area in Ethiopia were mainly attributed due to poor transportation and the use of poor marketing structures. Also, Omolo et al. (2011) in Kenya reported that the principal causes of PHL are many such as poor marketing systems. So, for the limitation of proper storage and marketing facilities, farmers are forced to sell produces at throwaway prices. Handling, packaging and transport practices for tomatoes depend on the market for which they are destined. Tomatoes destined for supermarkets have a much better developed post-harvest management system, using appropriate packaging, storage, and transportation in cold-chains. Informal traders who source directly from farmers do not have access to such systems, relying rather on makeshift packaging, storage, and transportation technologies. In addition to damaging the product, these improper practices also increase the risk of food safety hazards (Sibomana et al., 2016). Mtui (2017) also reported that poor harvesting method, delay in harvesting, damages during loading or off-loading, long distance to the market, poor road infrastructures, mode of transportation, storage condition, poor packaging materials, pest and diseases. The results further showed that delay in harvesting, pests and diseases were the major contributing factors of PHL at all levels of the supply chain.

The results of this study are also in line with Yeole and Curran (2016) who found that PHL of tomatoes are due to lack of low-cost cold storage facilities and improper packaging techniques at farm level. Additionally, at farm level the PHL were also due to mechanical damage to the produce during harvesting, packaging and transportation. The main problem that was seen at the farm level was that farmers used wooden crates for packaging and then transporting it to the nearest market to sell it directly to consumers. These wooden crates had sharp edges as well as improper ventilation leading to further PHL. Furthermore, at the retail stage there is no cold room to be used by both farmers and retailers for vegetables to be stored when they have not been sold on a particular day. Thus, this increases PHL.

6.1.4 Coping Mechanisms

The findings presented in Table 3 illustrate key coping mechanisms employed at different stages of the vegetable value chain to mitigate post-harvest losses. At the harvesting stage, farmers utilize harvest timing and shaded storage areas to prevent exposure to extreme heat, which can accelerate deterioration. These findings are similar to the findings of Kitinoja and Kader (2015), which emphasize that harvesting during cooler periods of the day and using temporary shading can reduce moisture loss and slow down respiration rates in fresh produce. Similarly, Affognon et al. (2015) highlight that inadequate harvesting practices contribute significantly to post-harvest losses, making proper timing and immediate shade storage crucial for maintaining vegetable quality. The Africities Food Project (2023) also found that poor timing of harvest results in excess moisture loss, this leads to rapid wilting and reduced shelf life in fresh produce.

At the packaging stage, sorting, grading, and the use of ventilated and standardized packaging materials were identified as key strategies to reduce damage and prolong shelf life. This aligns with Kasso and Bekele (2018), who found that sorting and grading help in removing damaged or diseased produce, thereby preventing the spread of spoilage. Additionally, Africities Food Project (2023) notes that small-scale traders often lack access to appropriate packaging materials, leading to high losses due to poor ventilation and physical damage. In line with the finding, Kiaya (2014) recommended handling, packaging and transportation practices that reduce mechanical damage and enhance shelf-life of fruits and vegetables. Therefore, standardizing packaging sizes ensures that produce is not overloaded or compressed, which is a leading cause of mechanical damage during handling and transportation (Majeed et al., 2020).

The transportation stage presents significant risks for post-harvest losses, and findings from this study indicate that farmers and traders attempt reduce PHL by covering produce with sacks or plastic sheets, reducing loading frequency, and pooling transport resources. These strategies are consistent with the findings of Ambuko et al. (2017), who emphasize that excessive handling and multiple loading points increase bruising and mechanical damage. The use of protective coverings is also supported by Mashau et al. (2022), who found that simple coverings can prevent sun exposure-related dehydration and nutrient loss. Furthermore, transport resource pooling reduces transportation costs while ensuring faster delivery of fresh produce, a method that has proven effective in reducing losses in low-income countries where cold-chain logistics are limited (Hodges et al., 2011). The Africities Food Project (2023)

similarly found that many smallholder farmers struggle with high transportation costs and inefficient logistics, which often force them to sell perishable produce at lower prices or face losses due to delayed deliveries.

6.1.4.1 Coping Mechanisms to Reduce PHL at Retail Stage

Considerations of crop type and variety are important, as these factors will affect the product's perishability and storage potential (Kiaya, 2014). While many technologies exist to reduce losses from harvest onward, innovations to reduce PHL can start before the farm-level with the development of varieties that have longer shelf-lives while maintaining their nutritious properties, taste, and texture. As a result of the losses incurred by the respondents in this study, most (40%) of them threw away the vegetables while others give away (15%). To mitigate the loss, the study found that most of the respondents 21% separated the injured, diseased or decayed produce from the fine produce while 20% kept the produce cool to avoid damage by the sun, 16% sell cheaply and 12% others avoided injury of the produce throughout the vegetable nodes.

Properly assessing the maturity and quality of produce before selling is a crucial step in reducing post-harvest losses, as it ensures that only high-quality and marketable vegetables reach consumers. Farmers and retailers often evaluate produce based on ripeness, color, firmness, and overall appearance to determine its suitability for sale. This process is essential because vegetables that are harvested at the wrong maturity stage tend to deteriorate faster, leading to significant losses. According to Kader (2013), harvesting at the optimal stage of maturity enhances the shelf life of perishable crops, reducing spoilage before they reach the consumer. This finding aligns with research by Affognon et al. (2015), which suggests that effective quality control mechanisms at the retail stage significantly contribute to reducing post-harvest losses along the value chain.

Mechanical injury to fresh produce is a major contributor to post-harvest losses at the retail stage. Physical damage, such as bruising, cutting, and compression. According to Hodges et al. (2011), bruised produce has a significantly higher respiration rate, leading to faster moisture loss and increased vulnerability to fungal and bacterial infections. In markets where handling practices are poor, post-harvest losses can be as high as 50% due to mechanical injuries sustained during transportation, packaging, and retail display. To minimize PHLs, proper handling techniques must be observed. Kitinoja et al. (2018) notes that training retailers and

transporters on proper handling significantly reduces damage and improves the longevity of fresh produce.

This study found that one of the most common coping mechanisms employed by retailers to avoid total losses is selling highly perishable produce at reduced prices (16%). For instance, one box of tomato which is usually sold at k150 can be sold cheaply for as low as k50 per box. This strategy allows retailers to recover at least part of their investment before the produce becomes unsellable. However, while price reduction helps minimize losses in the short term, it can also lead to financial instability for retailers in the long run. Research by Affognon et al. (2015) highlights that retailers often face difficult decisions between selling at lower prices and discarding produce that no longer meets market standards.

According to Figure 7, drying is one of the coping mechanisms used by the retailers. Mujumdar (2014) states that drying is one of the oldest and most effective food preservation methods, commonly used to extend the shelf life of leafy vegetables, tomatoes, and peppers. Drying is a widely used technique to preserve perishable crops, particularly in regions with inadequate refrigeration and cold storage facilities. By reducing the moisture content of vegetables, drying helps prevent microbial growth, enzymatic degradation, and premature spoilage. In local markets, sun-drying and solar drying are popular techniques among small-scale retailers, enabling them to salvage surplus produce that would otherwise go to waste. At Soweto market, most traders sell their fresh produce whilst drying their vegetables so that they can sell them at a later stage.

Sorting out injured or diseased produce is a critical step in preventing the spread of spoilage within a batch. When damaged vegetables are left mixed with healthy ones, microbial infections and ethylene emissions accelerate decay, leading to significant losses. Yahaya et al. (2019) found that early identification and removal of infected produce reduce microbial contamination by up to 40%. In addition, proper sorting and grading improve consumer confidence and market value, as customers are more likely to purchase produce that appears fresh and well-maintained.

Kitinoja et al. (2018) found that simple techniques, such as keeping produce in well-ventilated areas and avoiding direct sunlight exposure, significantly reduce post-harvest losses. These findings reinforce the importance of adopting affordable cooling solutions to preserve the quality of perishable vegetables in low-resource settings. Additionally, Proper storage plays a vital role in minimizing post-harvest losses, particularly in highly perishable crops. Poor

storage conditions expose vegetables to excessive heat, humidity, and microbial contamination, leading to rapid spoilage. Hodges et al. (2011) found that structured storage facilities reduce losses by up to 30% compared to traditional open-air storage. Moreover, Yahaya et al. (2019) report that adopting proper post-harvest storage techniques allows retailers to regulate supply and demand more effectively, avoiding overstocking and panic sales. These findings suggest that investment in proper storage infrastructure is a crucial strategy for reducing post-harvest losses and ensuring food security.

The results underscore the complementarity of diverse post-harvest handling techniques and practices used by farmers and actors in food supply chains. They also suggest diversification practices common among smallholder farmers mainly as a measure to spread risks and lower costs. Beckles (2012) noted that farmers and other actors in vegetable marketing chains choose a given post-harvest handling technique mainly to reduce losses and lengthen shelf life and not necessary to improve taste. Oparinde et al. (2016) also adds that farmers choose a particular post-harvest handling technique based on its efficiency and ability to enhance a crop's shelf-life. Similarly, the post-harvest handling choices identified in Lusaka region mainly helped reduce vegetable losses and lengthen shelf-life.

6.2 Conclusion

In conclusion, post-harvest losses in the vegetables were estimated to constitute up to 67.4% of the harvest. This study focused on commonly traded leafy vegetables in Lusaka's open markets which includes cabbage, rape, spinach, chinese cabbage, chibwabwa (pumpkin leaves) and tomatoes. PHL of vegetables is considered to be a major problem for farmers and other actors' involved along their supply chain. Therefore, the identification of the causes and magnitudes of PHL at each supply chain is very essential to reduce and control vegetables from deterioration, discarding, and cost increase and loss of nutritional value. The major identified causes of PHL of vegetables were mishandling (22.9%), high temperatures (20.1%), lack of storage facilities (17%), and pests/disease attacks (13.9%). The highest PHL of vegetables was found at retail level (49.5%) due to poor storage condition and poor processing practice. In addition, this level is the aggregate effects of poor harvesting, packaging, transportation and market condition cause such high losses. To reduce the PHL of vegetables, agricultural training and extension services should be given to farmers and other actors on proper pre harvest practice, postharvest handling, type of packaging used, transportation system and storage condition and marketing systems.

6.3 Recommendations

6.3.1 Policy and practice recommendations for PHL reduction

The study found that the highest critical loss point was obtained at retail level, the accumulative effects resulted from poor harvesting, packaging, transportation and handling at market causes high qualitative loss of vegetables.

1. Therefore, it is advisable that retailers and farmers should give attention to good storage and processing practice. In addition to this, all the stakeholders should give attention and have to be trained to good agricultural practices, proper harvesting methods, suitable packaging material, proper transportation and proper storage system and good marketing systems.
2. Also, in order to control these losses retailers and farmers must invest more in pre-sorting of their produce during marketing and also strictly monitor the quality of their produce before and after placing it on the shelf. These losses have a negative effect on the national production volumes as well as the perceived potential revenue.
3. Promote simple and cost-effective postharvest technologies among the supply chain actors in order to enhance adoption among the traders and smallholder farmers who are resource constrained and also lack relevant formal education.
4. Small scale farmers and retailers should have access to extension services to learn about measures to reduce PHL because vegetables can greatly contribute to food security and empowerment of vulnerable sectors of society like women and rural farmers.
5. In the absence of appropriate cold storage facilities, it is mandatory for farmers, retailers and customers to use appropriate postharvest handling practices to preserve desirable fresh produce quality characteristics and overall PHL reduction. This is especially useful in the study area since farmers did not have cold storage facilities and the fresh produce being transported using unrefrigerated transport. PHL reduction could provide market access, additional income to the farmers and ensuring the availability of a healthy diet.

6.3.2 Recommendations for further study

i. Future studies can also consider cost-benefit analysis of the existing post-harvest technologies through determining cost effectiveness and scale appropriateness at each locale and crop.

ii. A comprehensive study on the state of agricultural extension and training and their efficiency as well as comparative studies between regions, provinces or even similar communities could be important when advising policy-makers on the approach they can follow in developing rural agricultural livelihoods.

iii. Research on the development of a training programme for smallholder farmers, which emphasizes the economic benefits and incentives of PHL reduction, is of great importance. This action may contribute towards productivity, PHL reduction, market access, profitability and poverty alleviation in rural areas in the face of climate change, growing demand for vegetables and high food wastes universally.

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APPENDICES

Appendix I: Work Plan

The table below shows a work plan of this research from proposal development to final submission.

ACTIVITIES	Dec 2022	Jan-Mar 2023	Apr 2023	May 2023	Jun 2023	Jul-Oct 2023	Nov-Dec 2023	Jan- Apr 2024	May 2024
Proposal development									
Submission of the proposal at the school									
Presentation of proposal at the graduate forum									
Submission of protocol to Ethics Committee									
Data Collection									
Data Analysis									
Research Write up									
Submission of final dissertation									

Appendix II: Budget

Item Description	Quantity	Estimation of duration in days	Unit Cost (ZMK)	Total Cost (ZMK)
Stationary				
1. Note book	5		10	40
2. A4 Bond paper	1 ream		80	80
3. Pens	10		1	10
5. Stapler	1		40	40
7. File	1		30	30
8. Staples	1 box		10	10
Subtotal				**210**
Services				
9. Ethics				1000
10. Printing, Photocopying and binding of proposal				500
12. Data collection (Transport and Lunch)	1	3 visits per month open market to monitor data collection.	150	6,750
13. Printing, Photocopying and binding of reports				1,500
Subtotal				**9,750**
14. Contingence funds (10% of total)				1,078
GRAND TOTAL				**11,038**

Appendix III: Participant Consent Form

I……. agree/do not agree to participate on the research topic**: ESTIMATION OF POST-HARVEST LOSSES ON VEGETABLE VALUE CHAIN IN LUSAKA OPEN MARKET, ZAMBIA.**

I understand that the researcher subscribes to the following principles of carrying out research:

(1) Voluntary participation: That the participants may withdraw from the research at any time.
(2) Privacy: That confidentiality and the anonymity of participants will be protected at all times.
(3) Informed consent: That the research participants will at all times be fully informed about the research process and purpose. They are required to give written consent to participate in the research.
(4) Trust means: That the participants will not be subjected to any acts of deception or betrayal in the research process and in its published form.

Name: ……

Signature: ……..

Date: ……Place: …….

Witness

Name: ……

Signature: ……..

Date: ……Place: …….

Thanks for your willingness to participate in this study.

Appendix IV: Participants' Interview Guide

RESEARCH INTERVIEW GUIDE

INTRODUCTION

Thank you for participating in this interview. We are interested to find out the post-harvest losses of vegetables and tomato in Lusaka open markets and talking with you will help us better understand the concept. We really appreciate you taking the time to talk with us.

SECTION 1: GENERAL MARKET DYNAMICS

1. What are the main types of vegetables that are traded in the Lusaka open market?
2. What are the peak seasons for different vegetables in the Lusaka open market?
3. How do price fluctuations affect the handling and storage of vegetables?
4. How do traders coordinate with farmers to ensure a steady supply of vegetables?
5. What role do middlemen play in the vegetable value chain, and how do they impact post-harvest losses?
6. How does consumer demand influence the supply chain and potential post-harvest losses?
7. Are there specific days or periods when vegetable losses are higher? If yes, what causes this trend?

SECTION 2: FACTORS CONTRIBUTING TO POST-HARVEST LOSSES

8. What are the major factors contributing to post-harvest losses in the Lusaka open market?
9. How do weather conditions, such as temperature and humidity, affect post-harvest losses?
10. Are there any specific pests or diseases that contribute to post-harvest losses in the vegetable value chain?
11. How do traders detect spoilage in vegetables before purchasing from suppliers?
12. What are the common handling mistakes that lead to post-harvest losses?
13. Are there any traditional methods used to prevent spoilage and losses caused by pests and diseases?
14. How does access to pesticides or organic pest management techniques influence vegetable quality?

15. How do poor market infrastructure and lack of storage facilities contribute to post-harvest losses?

SECTION 3: HARVEST TO TRANSPORTATION STAGE

16. How does the duration of transportation and distance traveled impact the quantity of vegetable loss?

17. What are the most common transportation methods used to deliver vegetables to the market?

18. How do road conditions and infrastructure affect vegetable loss during transportation?

19. Are vegetables usually transported immediately after harvest, or is there a waiting period?

20. Are there specific vegetables that are more vulnerable to transportation-related losses?

21. What are the common causes of vegetable loss during the packaging and sorting stage?

22. Can you describe the processes involved in sorting, grading, and packaging of the selected vegetables, and how they impact vegetable loss?

23. Are there any quality standards or criteria set for the selected vegetables, and do they affect the quantity of vegetable loss?

24. Based on your experience or observations, what are some potential strategies or recommendations to reduce vegetable loss from harvest to packaging for transportation?

SECTION 4: RETAIL STAGE AND LOSS REDUCTION STRATEGIES

25. Are there specific factors that contribute to losses at the retail stage? If yes, please elaborate.

26. How do vegetable traders handle damaged or spoiled produce to minimize losses in the market?

27. What are some of the strategies that vegetable traders employ to minimize post-harvest losses in the market?

28. How do these coping mechanisms operate to mitigate losses?

29. Have you noticed any changes in loss reduction since the implementation of these coping mechanisms?

30. What are the challenges faced by vegetable traders in minimizing post-harvest losses in the market?

31. What role does hygiene and sanitation play in preventing spoilage and contamination of vegetables?

32. Are there partnerships between traders and local food processors to utilize surplus vegetables?

SECTION 5: STORAGE, TRAINING, AND INTERVENTIONS

33. Are there any existing initiatives or programs aimed at reducing post-harvest losses in the vegetable value chain in Lusaka?

34. Are there any storage facilities or practices that contribute to the reduction of post-harvest losses in the market?

35. Are there any training or capacity-building programs to educate farmers and traders about post-harvest loss reduction strategies?

36. How do traders access information on best practices for reducing vegetable losses?

37. What financial or technical support would traders need to invest in better post-harvest management?

38. What policies or regulations exist regarding post-harvest loss reduction in fresh produce markets?

39. What role can technology play in improving market efficiency and reducing vegetable losses?

40. What are the key stakeholders involved in addressing post-harvest losses in the vegetable value chain in Lusaka?

Appendix V: Approval from NASREC

THE UNIVERSITY OF ZAMBIA
DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

Great East Road Campus | P.O. Box 32379 | Lusaka10101 | Tel: +260-211-290 258/291 777
Fax: (+260)-211-290 258/253 952 | E-**mail**: director.drgs@unza.zm | Website: www.unza.zm

APPROVAL OF STUDY

IORG No. 0005376
NASRECREC IRB No. 00006465

7th June, 2023

REF NO. NASREC-2023- JUN – 001

Ms. Josephine Mwamba,
The University of Zambia,
School of Natural Science,
P.O. Box 32379,
LUSAKA.

Dear, Ms. Mwamba,

RE: "ESTIMATION OF POST-HARVEST LOSSES ON VEGETABLE VALUE CHAIN IN LUSAKA OPEN MARKET"

Reference is made to your protocol dated as captioned above. NASREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

REVIEW TYPE	ORDINARY REVIEW	APPROVAL NO. NASREC-2023 –JUN- 001
Approval and Expiry Date	Approval Date: 7th June, 2023	Expiry Date: 6th June 2024
Protocol Version and Date	Version - Nil.	6th June, 2024
Information Sheet, Consent Forms and Dates	• English.	To be provided
Consent form ID and Date	Version - Nil	To be provided

Recruitment Materials	Nil	Nil
Other Study Documents	Questionnaire.	

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

CONDITIONS OF APPROVAL

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.

- All unanticipated or Serious Adverse Events (SAEs) must be reported to NASREC within 5 days.

- All protocol modifications must be approved by NASREC prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.

- All protocol deviations must be reported to NASREC within 5 working days.
- All recruitment materials must be approved by NASREC prior to being used.

- Principal investigators are responsible for initiating Continuing Review proceedings. NASREC will only approve a study for a period of 12 months.

- It is the responsibility of the PI to renew his/her ethics approval through a renewal application to NASREC.

- Where the PI desires to extend the study after expiry of the study period, documents for study extension must be received by NASREC at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Documents received within 30 days after expiry will be labelled “late submissions” and will incur a penalty fee of K500.00. No study shall be renewed whose documents are submitted for renewal 30 days after expiry of the certificate.

- Every 6 (six) months a progress report form supplied by The University of Zambia Natural and Applied Sciences Research Ethics Committee as an IRB must be filled in and submitted to us. There is a penalty of K500.00 for failure to submit the report.

- When closing a project, the PI is responsible for notifying, in writing or using the Research Ethics and Management Online (REMO),both NASREC

- and the National Health Research Authority (NHRA) when ethics certification is no longer required for a project.

- In order to close an approved study, a Closing Report must be submitted in writing or through the REMO system. A Closing Report should be filed when data collection has ended and the study team will no longer be using human participants or animals or secondary data or have any direct or indirect contact with the research participants or animals for the study.

- Filing a closing report (rather than just letting your approval lapse) is important as it assists

NASREC in efficiently tracking and reporting on projects. Note that some funding agencies and sponsors require a notice of closure from the IRB which had approved the study and can only be generated after the Closing Report has been filed.

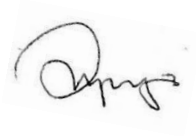
- A reprint of this letter shall be done at a fee.

- All protocol modifications must be approved by NASREC by way of an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by NASREC before they can be implemented.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of NASREC, we would like to wish you all the success as you carry out your study.

Yours faithfully,



Dr. Mususu Kaonda

VICE-CHAIRPERSON
THE UNIVERSITY OF ZAMBIA NATURAL AND APPLIED SCIENCES RESEARCH ETHICS COMMITTEE - IRB

CC: Director, Directorate of Research and Graduate Studies
Assistant Director (Research), Directorate of Research and Graduate Studies
Assistant Registrar (Research), Directorate of Research and Graduate Studies