ECONOMIC COST EVALUATION OF SELECTED VEGETABLE POST-HARVEST LOSSES IN BABATI DISTRICT TANZANIA

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DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and has not been submitted for an award of any degree in any other University.

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Recommendation

This thesis has been prepared under our supervision and submitted with our approval as University Supervisors.

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DEDICATION

I dedicate this research work to my blessed and ever supportive family, my husband Makolo Christopher Ludosha, son Ignatius Makolo Ludosha, daughter Janeth Makolo Ludosha and other family members.

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ABSTRACT

Vegetables remain an important source of nutrients in many parts of the world as they contain essential micronutrients, vitamins, antioxidants, and other health-related phytochemicals. They complement staple-based diets. Economically, vegetable production and marketing has a potential of high profit, employment, income generation and increasing commercialisation of the rural areas. However, vegetables are highly perishable and as such most actors in the vegetable value chain incur high post-harvest losses. In Tanzania, research on vegetable post-harvest losses is limited, yet post-harvest loss reduction may substantially contribute to higher returns leading to improving quality of lives of farmers and other actors in the supply chain. The study quantified the economic post-harvest losses of African egg-plant, amaranth and tomatoes along the supply chain, determined the principal causal factors contributing to selected vegetable postharvest losses and the factors influencingthe choice of post-harvest handling practices and techniques. A multi-stage sampling design was adopted for the ultimate selection of 200 vegetable farmers, 50 retailers and 50 wholesalers in Babati district. Descriptive statistics was used to determine the economic post-harvest losses of African eggplant, Amaranth and Tomato. The log-linear regression model was used to determine the principal causal factors contributing to vegetables post-harvest losses and multivariate probit model was used to determine factors that influence farmers' choice of post-harvest handling techniques and practices. Results showed that farm level vegetable post-harvest losses were higher compared to retail and wholesale market levels. This study found that economic postharvest losses incurred per individual per season for Egg-plant were TZS 408,800, TZS 111,650 and TZS 255,000; Amaranth TZS 181,500, TZS 23,650 and TZS 16,800 and Tomatoes TZS 918,500, TZS 237,000 and TZS 182,100 for farmers, retailers and wholesalers respectively. Field pests and diseases, delays in harvesting or selling and poor storage conditions were the principal causal factors contributing to vegetable postharvest losses along the supply chain. Lastly quantity harvested, education level and access to extension services had significant ($p<0.1$) positive influence on choice of post-harvest handling techniques while household income and farm-size had significant ($p<0.1$) negative influence. As a result, there is a need for equipped storage facilities, training on vegetable postharvest handling and marketing, and promotion of simple and cost-effective postharvest technologies among the supply chain actors.

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LIST OF ABBREVIATIONS AND ACRONYMS

Africa RISING	Africa Research in Sustainable Intensification for the Next Generation
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
HODECT	Horticultural Development Council of Tanzania
IFAD	International Fund for Agricultural Development
Kg	Kilogrammes
Km	Kilometre
MAFC	Ministry of Agriculture, Food Security and Cooperatives, Tanzania
MMA	Match Maker Associates Limited
PHL	Post-Harvest Losses
SME	Small and Medium Scale Enterprise
TAHA	Tanzania Horticultural Association
TZS	Tanzania Shillings
URT	United Republic of Tanzania
USAID	United State Agency for International Development

CHAPTER ONE
INTRODUCTION

1.1 Background information

The economy of Tanzania largely depends on agriculture. This sector accounts for about one quarter of the country's Gross Domestic Product (GDP). Moreover, it provides 85 per cent of exports and employs about 80 percent of the workforce (IFAD, 2015). Besides, the sector has strong inter-sectoral linkages with non-farm sectors through both backward and forward linkages. The sector is also important in moderating inflation, with food alone contributing about 50% to the household expenditure. Consequently, development of agriculture remains a key to the country's economic and social development (Ministry of Agriculture, Food Security and Cooperatives, Tanzania, 2012).

Despite its importance, the sector is dominated by smallholder farmers most of whom are resource constrained and produce mainly to meet household subsistence needs (Ministry of Industry, Trade and Marketing, 2008). As a result they have little or no marketable surplus for commercialization. Moreover, most smallholders rely on production of mainstream crops like cereals, root crops, banana, tea, pyrethrum, sisal, horticulture produce, coffee, cotton and tobacco (Salami *et al.*, 2010). Due to climate change, the performance of these crops has been declining over the years. In order to improve the livelihoods of smallholder farmers, the Tanzanian government and its development partners have been promoting smallholder commercialization through the adoption of high value crops such as horticultural crops. However, these horticultural crops have received relatively little policy attention, in spite of their overwhelming contribution to household incomes and foreign exchange.

Tanzania offers a wide range of horticultural produce such as vegetables, fruits, flowers, spices, medicinal and aromatic plants. The horticultural industry in Tanzania is the fastest growing agricultural subsector with a growth rate of 8-10% per annum. The subsector earns the country more than USD 354 million per year (TAHA, 2011). The growth of the industry is as a result of the increased nutritional importance and health awareness of the population, especially for fruits and vegetables (Dolan and Humphrey, 2000). Apart from their high nutritive value, other constituents of fruits and vegetables which deserve attention include antioxidants, bioflavonoids, flavour compounds and dietary fibre (APO and FAO, 2006). As a result of their highlighted nutritional and health benefits, the demand for horticultural produce in urban centres of both developed and developing countries has stimulated increased production by smallholder producers in developing countries (FAO, 2003). Consequently, Tanzania's level of production of fresh vegetables is increasing and there is still enormous production potential.

The country produces different types of vegetables such as edible roots, stems and leaves. Vegetables cultivated in Tanzania are either indigenous or standard (exotic) type. Typical indigenous vegetables produced by most farmers include African eggplant (*Solanuma ethiopicum*), African nightshade (*Solanum americanum*), Amaranth (*Amaranthus spp*), Bambara groundnut (*Vigna subterranean*), vegetable cowpea (*Vigna unguiculata*), Okra (*Abelmoschus esculentus*) and Pumpkin (*Cucurbita pepo*) (Weinberger and Msuya, 2004). Standard (exotic) vegetables include tomato (*Solanum lycopersicum*), cabbage (*Brassica oleracea var. capitata*), carrot (*Daucuscarota subsp. Sativus*), sweet pepper (*Capsicum annuum*), broccoli (*Brassica oleracea var. italica*), zucchini (*Cucurbita pepo var. cylindrica*), lettuce (*Lactuca sativa*), cauliflower (*Brassica oleracea var. botrytis*) (MMA, 2008).

In Tanzania, most vegetables are grown on a small scale despite the fact that horticultural crops present an alternative for farmers with too small cultivatable land to provide adequate field income from field crops. Besides vegetable crops grow faster and generate higher earnings per unit area in comparison to field crops (Zoss, 2009). Due to their higher earning potential, they present an alternative for farmers with too small cultivable land to provide adequate income from field crops (Mhango *et al.*, 2014; Keller, 2004). Following this, Africa RISING program funded by United States Agency for International Development (USAID) came up with an initiative of integrating vegetables into maize-based systems for improved nutrition and income of smallholder householder farmers. This initiative was implemented in Babati District of Manyara region, Tanzania.

The sustainable integration of vegetables into maize-based farming systems of Babati was aimed at enabling populations of semi-arid areas of Tanzania to capture nutritional and economic benefits. This is important as 90% of Babati district's population live in rural areas and depends on rain fed agriculture for their livelihood (Africa RISING, 2013). Africa RISING action research actively integrated and demonstrated vegetable farming and marketing practices so as to improve nutrition, health and economic outcomes in order to reduce the vulnerability of indigenous populations of the district. The project introduced innovations that promote farm household dietary diversity, while diversifying household income through high farm gate earnings accrued from target vegetable crops (that is, amaranth, tomato, and African eggplant).

Despite the importance of this initiative, vegetable production still faces the challenge of high post-harvest losses. Vegetables are highly perishable having 90 to 95% moisture content and have relatively short shelf life compared to most staple crops (Masabni *et al.*, 2009). The perishable nature of most vegetables leads to high post-harvest losses along the supply chain. Post-harvest losses in vegetables vary widely from commodity to commodity, place to place and become more complex depending on the marketing system. Post-harvest losses have a negative impact on the economic benefit derived from vegetable production (Weinberger and Acedo, 2009). These losses are higher in developing countries due to limited knowledge, skills, technologies, techniques and facilities for produce handling and processing.

Globally, more than thirty percent of all food that is produced is lost and/or wasted through inefficiencies in the food supply chain (Porter and Reay, 2015). In the developing world, the bulk of losses occur in the early stages of the supply chain, particularly, during harvesting and distribution (Stephen and Reay, 2015). Sub-Sahara Africa experiences losses between thirty to eighty percent of their perishable foods (fruits, vegetables, root crops) before consumption (Kitinoja, 2013). In contrast, in the developed world, this wastage is centred on the last stage in the supply chain, that is, the end-consumer throwing away food that is purchased but not eaten. Food losses and waste have a negative impact on the environment since they represent a waste of production factors and energy resources, and contribute to greenhouse gas emissions (Segre *et al.*, 2014).

Reducing post-harvest losses through application of appropriate post-harvest technologies improves incomes of farmers and marketers. It also makes diversification into vegetable production less risky and creates rural employment. Post-harvest technologies creates income generation opportunities through value-addition activities since post-harvest enterprises enhance productivity and competitiveness of vegetable industries, increases opportunities for export and sustains economic growth (Jaffee and Gordon, 1993). Minimizing post-harvest losses of already produced food is more sustainable than increasing production to compensate for these losses as it has high internal rates of return, effect on poverty, food security, health and sustainable use of resources.

1.2 Statement of the problem

The growing importance of vegetables offers an opportunity to many smallholders to improve their livelihood. Africa RISING action research actively integrates and demonstrates vegetable farming and marketing practices to nutrition, health and economic outcomes in order to reduce the vulnerability of indigenous populations in Babati district. As a result, many smallholders in Babati have integrated vegetables in their farming systems. Despite the growing importance of vegetable production and marketing, many smallholders and actors along the supply chain do not accrue sufficient returns due to high post-harvest losses. This is as a result of the perishable nature of vegetables that leads to a considerable gap between the gross production and net availability of vegetables with a large quantity being lost through post-harvest losses. Moreover, most smallholder farmers have inadequate knowledge on vegetable handling techniques. In Tanzania, researches on post-harvest losses are limited, yet reducing post-harvest-losses can substantially contribute to improved livelihoods of many farmers. In addition, there is a scarcity of information on the quantification of economic costs of vegetables along the supply chain which this study aims to address.

1.3 Objective of the study

1.3.1 General objective

The general objective of this study was to contribute to enhancing livelihoods of farmers in Babati district, Tanzania through reduction of vegetable post-harvest losses.

1.3.2 Specific objectives

The specific objectives of the study are:

1. To quantify the economic post-harvest losses of tomatoes, African egg-plant and amaranth along the supply chain in Babati District of Manyara region of Tanzania.
2. To determine the principal causal factors contributing to vegetable post-harvest losses along the supply chain in Babati District of Manyara region of Tanzania.
3. To determine the factors influencing farmers choice of post-harvest handling practices and techniques in Babati District of Manyara region of Tanzania.

1.4 Research questions

1. What economic losses (volume and value) of tomatoes, African eggplant and amaranth are incurred due to post-harvest losses along the supply chain?
2. What are principal causal factors contributing to post-harvest losses of tomatoes, African eggplant and amaranth along the supply chain?
3. What are the factors influencing the choice of vegetable post-harvest handling practices and techniques in Babati District?

1.5 Justification and significance of the study

Vegetable production has the potential to contribute to the reduction of food insecurity and poverty by increasing household income and food availability (Ochieng *et al.,* 2016). Reducing post-harvest losses for fresh produce has been seen as an important part of sustainable agricultural development efforts meant to increase food availability (Kader, 2005). Reducing post-harvest losses of vegetables improves local food and nutritional security, increases rural income, contributes to the increasing global food demand and increases resource use efficiency.

Therefore, the study aimed at quantifying vegetable post-harvest losses within the vegetable supply chain. Additionally, the study determined the driving factors of post-harvest losses within the vegetable supply chain and offered suggestions that can help enhance awareness creation of economic costs associated with current vegetable post-harvest losses as well as recommendations for solving the identified causes of the observed losses. These findings would be useful for farmers, researchers, investors, policy makers and government in formulating appropriate decisions, policies, institutions and determining the key areas of intervention in solving the problem of post-harvest vegetable losses.

1.6 Scope and limitation of the study

This study was restricted to analysis and documentation of economic cost quantification of African eggplant, amaranth and tomato postharvest losses in Babati District of Tanzania. Vegetable post-harvest losses include physical (quantity) and economic (quality) losses. The physical losses include weight and volume losses of downgraded produce while economic losses cover the produce that is unfit for human consumption. Although there are many species of vegetables, this study was only focused on Tomato, African eggplant and

Amaranth cultivated at the area of study under the framework of the Africa Research in Sustainable Intensification for the next Generation (Africa RISING) project being implemented by the International Institute of Tropical Agriculture (IITA) and World Vegetable Centre and other partners. The selection of the three vegetables was based on increasing the diversity of crops in farmer fields by including micro-nutrients rich vegetables to increase dietary diversity. The study focussed on farmers, wholesalers and retailers involved in vegetable farming and selling during August 2015 to February 2016 season.

1.6 Operational definition of terms

Indigenous vegetables - refers to a crop species or varieties genuinely native to Babati District, Tanzania or to a crop introduced into the region where over a period of time it has evolved, although the species may not be native

Standard vegetables - are those non-traditional crops which are not part of the customary diet of the local population and grown primarily for their high cash value and export potential.

Vegetable post-harvest losses - are a measurable reduction in vegetable quantity and quality which leads to the vegetable being regarded as unfit for human consumption and reduce households' nutrition and income security.

Quantity losses - are edible mass of vegetables lost due to apparent damage or spoilage.

Supply chain - refers to the range of activities performed to a product necessary to move the commodity from point of production to a point of consumption.

Household - A person or group of persons who reside in the same homestead/compound but not necessarily in the same dwelling unit, have same cooking arrangements, and are answerable to the same household head.

Smallholder - This study will consider smallholder farmers as those harvesting less than 5 tonnes of vegetable per season.

Retailer - A person that sells goods to the public in relatively small quantities for use or consumption rather than for resale.

Wholesaler - A farmer who buys vegetable from other farmers and bulks it for resale typically to retailers.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature on vegetable farming and its importance in improving the livelihoods of smallholder farmers of Babati district. The chapter also explores the principal causes of post-harvest vegetable losses along the supply chain as well as the factors influencing the choice of post-harvest handling techniques. A discussion on the theoretical and conceptual framework is also provided.

2.2 Importance of vegetables and vegetable farming

Vegetables remain an important source of nutrients in many parts of the world and offer advantages over dietary supplements because of low cost and wide availability (Kader, 2010). They contain essential micronutrients, vitamins, antioxidants, and other health-related phytochemicals that supplement staple-based diets (Afari-Sefa *et al.*, 2012). Due to their nutritional aspects, vegetables have captured the international spotlight in an unprecedented way, as persistent global hunger and under nutrition has underscored the need for urgent action (Afari-Sefa *et al.*, 2016). Vegetables like amaranth (*Amaranthus spp.*) and African eggplant (*S. aethiopicum*, *S. anguivi* and *S. macrocarpon*) have been shown to be rich in micronutrients such as iron, zinc, pro-vitamin A (Weinberger and Msuya, 2004).

These vegetables are gaining importance in local and global supply chains, generating revenue from export and increasing consumption in the local market (Aramyan *et al.*, 2014). Currently, smallholder farmers are finding production of vegetables as profitable in both rural and urban settings (Afari-Sefa *et al.*, 2012). Vegetable production in Eastern and Southern Africa has the potential to be highly profitable, provide employment opportunities, generate income and increase commercialization of the rural sector (Weinberger and Lumpkin, 2007). To realize this potential, farmers and other supply chain actors must improve the competitiveness of vegetable production and marketing to increase market share and profits. This requires public sector, development and policy upgrade efforts to improve competitiveness of the vegetable sector. Moreover, this has led to emerging private seed supply sector whereby new, improved, nutrient-dense indigenous and standard vegetable varieties are being released.

2.3 Causes of post-harvest vegetable losses along the vegetable supply chain

Post-harvest loss in terms of value and consumer quality attributes can occur at any stage between harvest and consumption (Abbas *et al.,* 2014). The major physiological, physical and environmental causes of post-harvest losses are high crop perishability, mechanical damage, excessive exposure to high temperature, relative humidity and rain. Other causes are contamination by spoilage fungal and bacteria; invasion by birds, rodents, insects and other pests; and inappropriate handling, storage and processing techniques (World Bank, FAO and NRI, 2011). Moreover, losses may be aggravated by poor infrastructure, harvesting methods, post-harvest handling procedures, distribution, sales and marketing policies (World Bank *et al*., 2011).

Poor handling, unsuitable packaging and improper packing during transportation are the cause of bruising, cutting, breaking, impact wounding, and other forms of injury in fresh fruits and vegetables (APO and FAO, 2006; Choudhury *et al*., 2004). Mechanical injury can be internal such as rotting inside the vegetable and not visible from outside. This leads to spoilage of produce since its physiology is compromised. Also mechanical injury can be external such as cuts and bruising that pave way for infections by pathogens and insects which may lead to diseases (Sarpong *et al*., 2011).

Post-harvest losses in vegetables differ along the supply chain. Farmer's losses are due to high disease incidence and hot weather during harvest. While middlemen experience loss due to oversupply of vegetables and failure to sell all produce as well as damage during transportation. Similarly, retailers consider failure to sell all produce as a major reason for loss, in addition to poor quality of purchased produce (Weinberger *et al*., 2008). A study on knowledge and losses of fruits in Bagamoyo Tanzania found that mechanical injury, transportation loss and microbial damage were the main post-harvest losses along the supply chain (Kereth *et al.,* 2013). Also other factors such as packaging materials, sunlight, hygienic conditions and duration of selling the produce were also observed (Kereth *et al*., 2013).

The environmental conditions under which produce is stored have a major effect on the storability as well as the quality of the produce. Temperature, relative humidity and moisture as well as solar radiation are but a few of the environmental characteristics that affect post-harvest losses (Egyir *et al.*, 2011). However, high cost of using adequate storage devices deters farmers from using them hence leading to high post-harvest losses (Egyir *et al*., 2011).

As a result inadequate storage facilities at producing or marketing centres leave the produce to natural causes of losses such as decay by organisms, respiration, transpiration and other biochemical reactions (Sudheer and Indira, 2007).

Cold chain failure in many developing countries are due to unreliability of power supply, lack of proper maintenance, inefficiency utilization of cold storage and refrigerated transport facilities (Kader, 2010). Small and Medium Enterprise Competitiveness Facility (SCF) (2008), reported that horticulture post-harvest losses in Tanzania, especially for tomatoes, ranges from about 30 to 50 percent due to poor handling during transport and storage. This is similar to post-harvest losses experienced in India where about 30 percent of the fruits and vegetables grown get wasted annually due to gaps in the cold chain such as poor infrastructure, insufficient cold storage capacity, unavailability of cold storages in close proximity to farms and poor transportation infrastructure (Maheshwar and Chanakwa, 2006).

Packing and packaging methods can greatly influence air flow rates around the commodity, thereby affecting temperature and relative humidity management of produce while in storage or in transit (Kader and Rosa, 2004). A study on post-harvest handling techniques of fruits in Bagamoyo Tanzania found that most of farmers pack their fruits in plastic sacks, wooden bamboo basket and in wooden crates due to that they are cheap and mostly available (Kereth *et al.*, 2013). Use of different types of sacks does not protect the fruits from mechanical damage due to large congestion and high heat which in turn accelerates mechanical damage and microbial attack (Kereth *et al.*, 2013; Kader and Rolle, 2004).

Transport losses are usually caused by unsuitable transport containers, poor roads as well as lack of feeder roads, methods of loading and arrangement of produce in vehicle (Egyir *et al.*, 2011). Mechanical injuries during transportation occur during loading, unloading, stacking operations or from shocks and vibration during transportation (Prussia *et al.*, 2009).

Therefore, this study adopted loss assessment methodologies that included; quantifying the level of production through commodity system assessment method by identifying the most important causal factors contributing to post-harvest losses and adopting a supply chain approach by understanding how much of the initial produce reaches the particular step of the value chain. Also consideration of the interaction of the various loss agents at the particular level in the supply chain was taken.

2.4 Estimation of the quantity and value of post-harvest losses

Post-harvest losses in horticultural crops can be either quantitative or qualitative. Qualitative losses (such as loss of caloric and nutritive value, loss of acceptability by consumers, and loss of edibility) are more difficult to assess than quantitative losses of fresh fruit and vegetable crops. While reduction of quantitative losses is a higher priority than qualitative losses in developing countries, the opposite is true in developed countries where consumer dissatisfaction with produce quality results in a greater percentage of the total post-harvest losses (Kader, 2005). Calculation of these losses are related to improper temperature management and the post-harvest handling chain which includes all steps between harvesting and consumption such as sorting, cleaning, packing, cooling, storage, transport and processing (Kitinoja and Al Hassan, 2012).

Generally, there are no universally accepted methods for evaluating post-harvest losses of fresh produce (Egyir *et al.*, 2008). Currently there is no agreed methodology for consistent measurement of post-harvest food losses due to differences in social, economic, environmental and political differences among different regions (Aulakh and Regmi, 2013). Most of the studies in the last three decades have focused only on the storage stage of the supply chain, ignoring other important stages which also contribute to post-harvest losses. Ignoring other important stages like harvesting, transportation and processing which also contribute to overall post-harvest losses represent gap in the estimation procedure which needs to be addressed for more reliable future estimates. The stages of post-harvest handling and length of supply chain depend on the perishability and physical properties of a crop (Aulakh and Regmi, 2013). African Post-harvest Losses Information System (APHLIS) provides a valuable framework for estimating post-harvest losses in South and East Africa but the framework is mainly restricted to the large grain borer infestation and to seven major crops (Rembold *et al.,* 2011).

Commodity system analysis enables the identification of different steps that occur from production to marketing of the product. It consists of pre-harvest and post-harvest operation where by post-harvest operations give general representation of supply chain (Aulakh *et al.*, 2013). The post-harvest aspect of the commodity system gives the general representation of the commodity's supply chain and can therefore be a useful approach to aid holistic assessment of post-harvest losses. The use of systematic analysis of the production and post-harvest handling of each commodity provides logical first step towards identifying sources of losses and post-harvest solutions (Kader, 2005). The purpose of using commodity system approach is to de-categorize all activities in the post-harvest system (post-harvest handling and marketing) of the commodity under observation into their smallest bit and then directly measure their contribution in the overall losses observed (Kamarulzaman *et al.*, 2014).

Critical stages approach which is similar approach to commodity system was used by Aulakh *et al.* (2013) through identifying critical factors responsible for post-harvest losses at each stage of food supply chain and their contribution to the total post-harvest losses. Both qualitative and quantitative losses along the supply chain start at the time of harvest to its consumption due to waste or inadvertent losses along the supply chain. Factors that contribute to post-harvest losses range from mechanization of practices, processing, weather conditions, production practices, management decisions, transportation facilities, grading, infrastructure, consumer preferences and availability of financial markets. The losses along supply chain incurred at each step vary depending upon the organization and technologies used in the food supply chain (Aulakh *et al.*, 2013).

The study by Affognon (2015) provided critical and comprehensive review for synthesis of the evidence on the nature, magnitude, costs, and value of current post-harvest losses of various groups of commodities along the supply chain in Sub-Saharan Africa. The study was based on a comparative analysis across commodities (that is: cereals, pulses, fruits, roots and tubers, vegetables, animal products, and oil crops), value chains and different contexts in six African countries (Benin, Ghana, Kenya, Malawi, Mozambique and Tanzania). The study used the meta-analysis approach of consolidating available evidence form many studies conducted in the past. It identified gaps in post-harvest losses assessment and mitigation, and their implications to the studied value chains.

According to a study done in Lao on tomato, yard long bean, cucumber and chill by Genova *et al.* (2006), the estimation of post-harvest losses at famers' level was quantified and calculated as a percentage based on total harvested quantity. Whereas, post-harvest losses for collectors, whole sellers and retailers was estimated as the difference between the quantity purchased and quantity sold in relation to total quantity purchased. The value of loss experienced was the actual loss in kilograms multiplied by the average selling price.

Another study on post-harvest losses in supply chain for vegetables (chilli pepper and tomato) in Vietnam by Weinberger (2006) collected monthly observations for collectors, wholesalers and retailers for an entire year. Post-harvest losses at the farm level was quantified and calculated as a percentage based on total harvested quantity. For collectors, wholesalers and retailers, loss was estimated as the difference between quantity purchased and quantity sold in relation to total quantity purchased. To obtain the value of post-harvest losses experienced, actual loss in kilogram (kg) was multiplied with the average selling price. Amartey (2013) conducted a study on post-harvest estimation of selected vegetable crops in Ghana. The value of the quantity of post-harvest losses was calculated as the product of the average estimated quantity lost and the unit price.

Another study conducted in Karnataka on post-harvest losses in food grains at different stages of their handling assessed the extent and magnitude of losses and identified the factors responsible for such losses. Information about post-harvest losses was obtained from the farmers during operations; harvesting, threshing, cleaning/winnowing, and drying. The information on losses was collected from the farmers, market intermediaries, storage and transit. The total post-harvest losses were estimated as a sum of all these losses. Multiple linear regression model was used to examine the factors affecting post-harvest losses at farm level in food grains (Basavaraja *et al.*, 2007).

Ahmed *et al.* (2015) quantified the post-harvest losses of Kinnow (citrus fruit) at various stages of the supply chain. The study estimated post-harvest losses in Kinnow at farm, wholesale market and retail levels. To estimate the losses of Kinnow descriptive statistics were used and double log form regression at three different levels (farm, wholesale market and retail levels) was employed to determine the major determinants of citrus post-harvest losses.

Aulakh *et al.* (2013) adopted a functional approach by identifying critical factors responsible for post-harvest losses at each stage of the food supply chain. According to Aulakh *et al.* (2013) total post-harvest losses was equal to sum of post-harvest losses at each stage of the food supply chain represented as:

Total post-harvest losses $= \Sigma Si = \Sigma f(Xi)$...(i)

Where:

Si denotes the losses at each critical stage (harvesting, food storage, processing, packaging and sales) of food supply chain.

Xi stands for the factors affecting losses (moisture, weather, pest/diseases, infrastructure, size of operation, level of mechanization, quality management, operator characteristic and access to capital) at each stage, and ***i*** represent critical stages from harvesting to sales.

Based on the reviewed literature, this study will use commodity system in identifying critical factors responsible for vegetable post-harvest losses at each stage of supply chain and their contribution to the total vegetable post-harvest losses.

2.5 Post-harvest handling techniques used to minimize post-harvest vegetable losses

Most of the factors that contribute to post-harvest losses are known. As much as different technologies have been developed to reduce these losses, they have not been widely implemented particularly among the smallholders. This is due to a myriad of factors including inadequate marketing systems, transportation facilities, government regulations and legislations, unavailability of needed tools and equipment, lack of information and poor maintenance (Kader, 2005). In most cases, solutions to existing problems in the post-harvest handling system require use of available information and application of available technologies at the appropriate time and overcoming the socio-economic constrictions is essential in reducing post-harvest food losses.

However, the choices of post-harvest handling techniques are affected by several factors. For example farmers' choice of storage techniques is influenced by quantity of grain stored, education, gender of the farmer, capital invested and price of grains (Okoruwa *et al*., 2009). Using a probit model, a study on factors influencing choice of pesticides used by grain farmers in Southwest Nigeria found that age of household head, education, farming experience, price of grains and quantity of grains consumed were significant factors that influences the choice of pesticides. Furthermore, Okoruwa *et al.* (2009) found that the choice of pesticide used by farmers was influenced by quantity of grains harvested, cost of pesticide and investment cost. Conteh *et al.* (2015) concluded that education level, household size, and type of grain grown positively influenced adoption of grain storage technologies while mode of acquisition of farmlands and farming systems had negative influence on the adoption of the technologies.

Temperature management is the most effective tool for extending the shelf life of fresh horticultural commodities (FAO, 2004). But high cost of using adequate storage devices deters farmers from using them hence leading to high post-harvest losses (Egyir *et al.* 2011). The use of cold chain for perishable foods product during the post-harvest steps such as harvest, collection, packing, processing, storage, transport and marketing is widely used in developed countries and can be highly cost effective compared to increasing production (Kitinoja, 2013). Poor infrastructure for storage, processing and marketing in many countries of the region contributes to a high proportion of post-harvest losses which average between 10 and 40 percent. Major infrastructural limitations also continue to impose severe constraints to domestic distribution as well as to the export of horticultural produce (APO, 2006). A study by Mwebaze and Mugisha (2011) in Uganda found out that farmers prefer local post-harvest reduction methods instead of government improved post-harvest technologies because producers do not know whether the benefits of the latter will surpass the cost.

2.6 Theoretical and Conceptual Framework of the Study

2.6.1 Profit maximization Theory

Unlike growing of major food crops among smallholder farmers in Africa, commercial orientation in horticultural crops like flowers, fruits and vegetables grown takes precedence over food self-sufficiency. This is because most of these crops are grown mainly for sale. Therefore, profit maximization theory would better explain losses associated with vegetable farming compared to utility maximization theory.

Post-harvest losses are often economic rather than complete physical loss as it has been assumed to be the case (Affognon, 2015). Reducing post-harvest loss increases yield and profitability to farmers. Farmers will minimize post-harvest losses (PHL) when they have financial motivations to do so (Hodges *et al.* 2011). However, most of rural farmers are faced with high opportunity costs of capital and liquidity constraints due to competing demands for limited cash resources (Affognon, 2015). Therefore, PHL mitigation plays an important role on farmers' decisions based on diversification and supply responses to risk in agricultural production.

This study models farmer's problem using a standard microeconomic structure (see for example Varian 2010) with focus on vegetable post-harvest losses. Consider a competitive firm (farmer) with the production function of two inputs X_1 and X_2. Where by X_1 is the input to vegetable PHL mitigation and X_2 are all inputs to vegetable production. In the short-run $\overline{X_2}$ is fixed.

$$Y = f(X_1 \overline{X}_2)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(ii)$$

Consider the short-run profit maximization problem behaviour

$$\pi = PY - W_1 X_1 - W_2 \overline{X}_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(iii)$$

Where $Y = f(X_1 \overline{X}_2)$

W_1 Cost of post-harvest loss mitigation such as sorting, grading, cooling, packaging, storage and transporting.

W_2- Cost of all inputs used in vegetable production.

This expression can be solved for *Y* to express output as a function of *X_1* as shown in *equation iv*:

$$Y = (\ \pi/p\ ) + (\ w_2/p * \overline{X_2}\ ) + (\ w_1/p * X_1\ )\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(iv)$$

Where $(\ \pi/p_1\ ) + (\ w_2/p_1 * \overline{X_2}\ )$ depicts the Y intercept. $(\ w_1/p_1\ )$ is the slope of profit line (π), which is the marginal product of post-harvest losses mitigation. Focusing on price of vegetables, farmers receive greater benefits from loss mitigation when vegetable prices rise and lower benefits when prices fall. Thus the farmers accept vegetable post-harvest loss because the costs to mitigate loss are greater than the benefits.

Substituting constraint (v) into objective function below:

$$\pi = Pf(X_1 X_2) - W_1 X_1 - W_2 \overline{X}_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(v)$$

The inputs demand $X_1^* = X_1(P, X_1 \overline{X}_2)$ whereby X_1^* the vector of input that maximizes profit is given *P*, *X_1* and $\overline{X_2}$.

The condition for the optimal choice of input factor X_1:

If X_1^* is the profit-maximizing choice of factor *X_1*, then the output price multiplied by the marginal product of factor *X_1* should equal the price of factor *X_1*.

$$pMP_1(X_1^*, \overline{X}_2) = W_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(vi)$$

If the value of marginal product exceeds its cost, then profits can be increased by increasing input X_1. If the value of marginal product is less than its cost, then profits can be increased by decreasing the level of input X_1. This means that at a profit maximizing choice of inputs and outputs, the value of the marginal product, $pMP_1(X_1^*, X_2)$ should equal the factor price, W_1.

2.6.2 Conceptual Framework

This study is conceptualized based on literature review and Commodity System Assessment Method (CSAM) (Neese *et al.*, 2013). After the harvesting activity vegetables are moved from the point of production (farm) to point of consumption. Vegetables are moved along the supply chain through different supply chain actors such as farmers, collectors, processors, whole sellers and retailers. Different activities associated with moving the vegetables are performed by supply chain actors and they include harvesting, sorting and grading, packaging, transporting and storage. Vegetable losses can occur at any point along the supply chain and to any supply chain actor. The causes of post-harvest vegetable losses at each activity undertaken on a produce are more or less similar. Post-harvest vegetable losses along the supply chain are attributed to harvesting method (mechanical or not mechanical), time of harvesting, loading/off-loading, packaging, packing during transportation (grates, bags), mode of transportation (refrigerated/not refrigerated), storage (refrigerated or not refrigerated) and contamination (washing). Different measures such as shade, maturity indices, use of improved containers, sorting/grading, solar drying and hand-washing/hygiene can be undertaken to reduce the magnitude of losses. Reducing the magnitude of post-harvest losses in vegetables provides incentive to producers and consumers in form of nutrition, health and economic benefits.

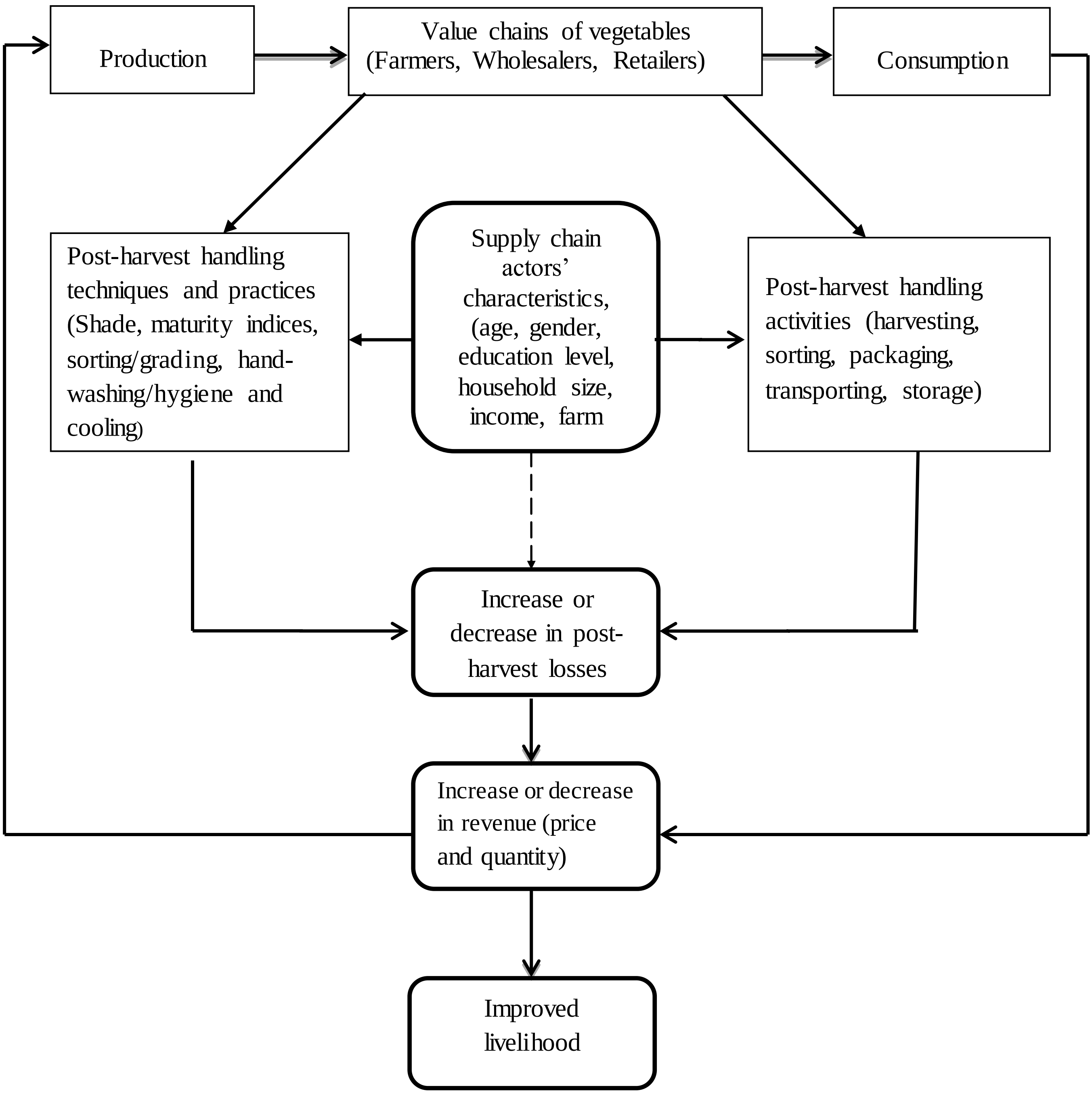

Figure 1: Variables affecting **post-harvest losses in vegetables**

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter presents the research methods that were used in collecting and analysing data from vegetable farmers in Babati district, Manyara region, Tanzania. It begins with a description of the study area, followed by an explanation of the sampling technique and the sample size from which data was collected. The section on data collection methods explains the tools that were used for data collection and the variables that were measured for the empirical analysis. The analytical framework is based on empirical models giving a justification for selecting particular models.

3.2 Study area

This study was conducted in Babati district, Manyara region, Tanzania. Babati district is situated in Northern Zone of Tanzania, and located between latitude 3° and 4° south and the longitude 35° and 36°. The region was chosen because of its potential in vegetable farming. Babati district consists of four divisions, 21 wards and 82 villages. The population of Babati district in 2012 was 405,500 (312,392 for Babati District Council and 93,108 for Babati Town Council) (URT, 2013). The periodic growth rate for the district was about three percent per year between 2002 and 2012. An agricultural survey conducted by the United Republic of Tanzania through the ministry of agriculture in 2007/08 revealed 63,816 agricultural households, of which fifteen percent were female-headed (URT, 2012).

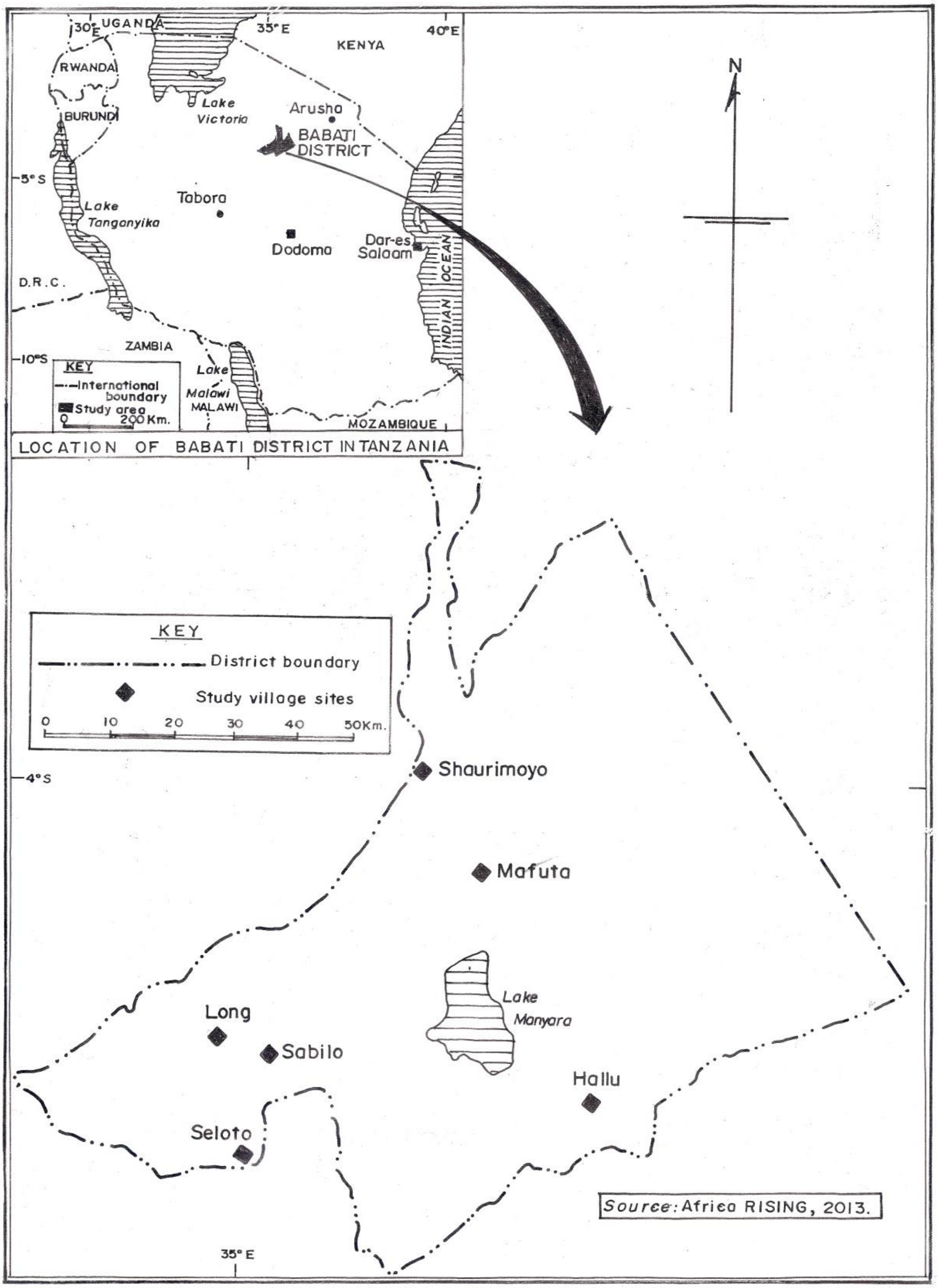

Figure 2: A map of Babati District

3.3 Sampling procedure

A multi-stage sampling design was adopted for the ultimate selection of vegetable farmers. First stage Babati district from Manyara region was purposively selected based the agro climate, maize based system and population and livestock density. Second stage, five villages (Matufa, Seloto, Berma, Galapo and Babati town) were purposively selected based on their vegetable production, constraints and opportunities. The number of smallholder vegetable farmers was sampled from each village using stratified sampling. The selected farmers were those who had integrated vegetables into maize based system under Africa RISING action research.

3.4 Sample size

The desired sample size for farmers was determined using a formula by Kothari (2004).

$$n = \frac{Z^2 pq}{e^2} \text{...} (vii)$$

Where by n =Sample size, p = 0.5 (expected proportion of vegetable farmers under Africa RISING action research), q = (1-0.5) = 0.5, Z = 1.96 at 95% confidence level and e =7% (allowable margin of error).

The sample size for farmers was;

$$n_1 = \frac{(1.96)^2 x 0.5 x 0.5}{(0.07)^2} = 196 \text{...} (viii)$$

Where;

n_2 =Sample size for wholesalers/retailers, p=0.1 (10% is the expected proportion of vegetable wholesalers and retailers), q=(1-0.1)=0.9, Z=1.96 at 95% confidence level and e =8% (allowable margin of error).

Wholesalers and retailers were chosen purposively across all the target villages.

The sample size for wholesalers and retailers was as shown in equation ix.

$$n_2 = \frac{(1.96)^2 x 0.1 x 0.9}{(0.08)^2} = 54 \text{...} (ix)$$

3.5 Data collection

Data for this study was collected using structured questionnaires. In order to get data for loss estimates this study adopted loss assessment methodologies that included; quantifying the level of production, identifying the most important causal factors contributing to post-harvest losses and adopting a supply chain approach by understanding how much of the initial produce reaches the particular step of the value chain. Consideration was also given to the interaction of the various loss agents at the particular level in the supply chain. The target farmer households were 196 according to the computed sample size however a total of 200 questionnaires were administered to respondent farmers and since they were complete and with the right information they were all considered for the analysis. Additionally, structured questionnaire was used to collect data from 50 wholesalers and 50 retailers.

3.6 Data analysis

To achieve the objectives of this study, the collected data was cleaned, organized and analysed using IBM Statistical Package for Social Sciences (SPSS) Statistics version 20 and Stata version 12 SE for windows. Specifically, descriptive statistics and inferential statistics were employed to analyse data and address the study objectives.

3.6.1 Quantification of economic post-harvest losses of Tomatoes, African egg-plant and Amaranth.

Descriptive statistics such as averages, frequencies, percentages and standard deviations were used to determine the economic post-harvest losses of African eggplant, amaranth and tomato. African eggplant, amaranth and tomato post-harvest losses at farm level were quantified and calculated as kilograms based on total harvest. For wholesalers and retailers post-harvest losses were estimated as the difference between quantity purchased and quantity sold in relation to total quantity purchased. However, wholesalers and retailers post-harvest losses estimates were generalized as the total percentage share of the post-harvest loss by season. To estimate the value of post-harvest losses of African eggplant amaranth and tomato; the average quantity of post-harvest losses obtained was multiplied by average price of the vegetables.

3.6.2 Determining the principal causal factors contributing to post-harvest losses along the vegetables supply chain.

The log-linear Regression Model was used to determine the principal causal factors contributing to post-harvest losses along the vegetables supply chain in Babati district. The model was specified at farm level, wholesalers and retailers. Quantity of post-harvest losses was used as the dependent variable to farmers, wholesalers and retailers.

At farmers:

$$LnY = \beta_0 + \beta_1 Gender + \beta_2 Age + \beta_3 Educ + \beta_4 HHsize + \beta_5 Farmsize + \beta_6 Farm\exp + \beta_7 Distmrk + \beta_8 Loadn + \beta_9 Fieldp\&d + \beta_{10} D_1 + \beta_{11} D_2 + \beta_{12} D_3 + \beta_{13} D_4 + \beta_{14} D_5 + \varepsilon .... (x)$$

At wholesalers:

$$LnY = \beta_0 + \beta_1 Gender + \beta_2 Age + \beta_3 Educ + \beta_4 HHsize + \beta_5 Farmsize + \beta_6 Farm\exp + \beta_7 Distmrk + \beta_8 Loadn + \beta_9 Fieldp\&d + \beta_{10} D_1 + \beta_{11} D_2 + \beta_{12} D_3 + \beta_{13} D_4 + \beta_{14} D_5 + \varepsilon .... (xi)$$

At retailers:

$$LnY = \beta_0 + \beta_1 Gender + \beta_2 Age + \beta_3 Educ + \beta_4 HHsize + \beta_5 Farmsize + \beta_6 Farm\exp + \beta_7 Distmrk + \beta_8 Loadn + \beta_9 Fieldp\&d + \beta_{10} D_1 + \beta_{11} D_2 + \beta_{12} D_3 + \beta_{13} D_4 + \beta_{14} D_5 + \varepsilon .... (xii)$$

Table 1: Description of variables used in multiple linear regression

Code Variable	Variable	Variable type	Unit of measurement	Expected sign
Dependent variables				
Y	Quantity of vegetable post-harvest losses at farm level, wholesale and retail	Continuous	Kilogram	+
Independent variables				
Gender	Gender of the household head	Dummy	1=Male, 0=Female	+/-
Age	Age of the household head	Continuous	Years	+
Educ	Education level	Continuous	Years	+
HHsize	Household size	Continuous	Number of persons	+
Farmsize	Farm size allocated for vegetable farming	Continuous	Acre	+/-
Farmexp	Vegetable farming experience	Continuous	Years	+
Distmrk	Distance to the market	Continuous	`Kilometre	+/-
Loadn	Loading/off loading	Continuous	Kilogrammes	+/-
FieldP&D	Pest and diseases	Continuous	Kilogrammes	+/-
Ptime	Picking time	Dummy	D_1 = 0 picked in Evening D_1 = 1 picked in Morning,	+/-
Harmethod	Harvesting method	Dummy	D_2 = 0 harvested manually D_2 = 1 With scissor	+/-
Storage	Storage condition	Dummy	D_3 = 0 normal temperature D_3 = 1 controlled temp.	+/-
Packing	Packaging materials during transportation	Nominal	D_4 =0 plastic bag D_4 =1 Bamboo basket D_4 = 2 Wooden create D_4 = 3 Plastic create	+/-
Transmode	Mode of transportation (type of transportation used)	Nominal	D_5 = 0 Head, D_5 =1 Cart D_5 =2 Car	+/-
Natroad	Nature/type of the road	Nominal	D_6= 0 Weather road, D_6=1 Murram, D_6= 2 Tarmac	+/-

ε = Disturbance term, $\beta_0$is Constant term
β_1, β_2, β_3, β_4, β_5,β_6 are the coefficients of estimates in the model

3.6.3 Determining the factors influencing farmer's choice of post-harvest handling practices and techniques.

Multivariate Probit Model was used to analyse the factors that influence farmers' choice of post-harvest handling techniques and practices. In a single statistical model, information on farmers' choice of post-harvest handling techniques and practices does not alter the likelihood of a farmer's choice of another post-harvest handling technique and practice. The use of particular post-harvest handling practice and technique is choice based, in that a household could opt to use a combination of practices based on the perceived benefit that can be derived from it. Farmers' can also use more than two post-harvest handling techniques and practices. For instance, a farmer could combine shade and maturity indices or improved containers and sorting/grading or solar drying and cooling.

Probit and Logit models are commonly used to model decisions which involve two complete mutually exclusive alternatives (Gujarati, 2007). However choice decisions are not bound between two alternatives. The selection of post-harvest techniques is such where Probit and Logit models may not be so helpful in analysis. In such cases, advanced models like multinomial Probit and Logit can be used. Multinomial Logit is an appropriate technique especially when the dependent variable categories are not ordered (Gujarati, 2007). Joseph (2010) further explains that Multinomial Logit (MNL) model is similar to the Binary Logit model, except that the dependent variable in this case will have multiple discrete outcomes. In addition the technique of MNL can be used to study nominal categories in which the regressands are unordered or unranked unlike the ordinal Logit models that models only ordered response categorical variables (Gujarati, 2007).

However, the choices of post-harvest handling techniques and practices are not mutually exclusive as a farmer may use more than one post-harvest handling technique and practice at the same time and therefore the random error component of post-harvest handling technique and practice may be correlated. The shortfall of this technique is that all multinomial replications of the multivariate choice system have the problem in interpreting the influence of dependent variables on the original separate post-harvest techniques. Therefore multivariate probit model seemed to be the best model for this objective because it allows possible contemporaneous correlation in the choice to use the combination of post-harvest handling technique and practices simultaneously.

The Multivariate model adopted is characterized by a set of n binary dependent variables Y_i such that

$$Y_i = 1 \; if \; x^1\beta_i + \varepsilon > 0$$

$$= 0 \; if \; x^1\beta_i + \varepsilon \leq 0, i = 1,2, \dots, n, \text{ -- } (xiii)$$

Where x is a vector of explanatory variables, $\beta_1, \beta_2, \dots, \beta_n$ are conformable parameter vectors, and the random error terms $\varepsilon_,$, ε_2, … ε_n are distributed as multivariate normal distribution with mean of zero, unitary variance and a contemporaneous correlation matrix.

Table 2: Description of variables to be used in Multivariate Probit Model

Code Variable	Variable	Variable type	Unit of measurement	Expected sign
Dependent variables				
Matind	Maturity indices	Dummy	1=Yes 0=No	+/-
Shade	Shade	Dummy	1=Yes 0=No	+/-
Sortin	Sorting/grading	Dummy	1=Yes 0=No	+/-
Washing	Washing	Dummy	1=Yes 0=No	+/-
Cooling	Cooling	Dummy	1=Yes 0=No	+/-
Independent variables				
Gender	Gender of the household head	Dummy	1=Male, 0=Female	+/-
Age	Age of the household head	Continuous	Years	+
EducL	Education level	Continuous	Years	+
HHsize	Household size	Continuous	Number of persons	+
Farmsize	Farm size allocated for vegetable farming	Continuous	Acre	+/-
Fexper	Vegetable farming experience	Continuous	Years	+
Distmrk	Distance to the market	Continuous	Kilometre	+/-
Vegqnty	Quantity of vegetable harvested/bought	Continuous	Kilogram	+/-
Vprice	Price of vegetables	Continuous	Value in TZS	+
HH. income	Household income	Continuous	Value in TZS	+
Extension	Extension services on post-harvest handling	Dummy	1=Yes 0=No	+
Transaset	Ownership of transportation asset	Dummy	1=Yes 0=No	+
Natroad	Nature /type of the road	Dummy	1=Yes 0=No	+/-

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

The chapter begins with a description of the socioeconomic characteristics of the sampled households in relation to vegetable farming. The quantification of economic post-harvest losses of African egg-plant, amaranth and tomatoes are discussed. This is followed by an assessment of the determinants and discussion of the principal causal factors contributing to vegetable post-harvest losses. Lastly factors influencing farmers' choice of post-harvest handling practices and techniques are determined.

4.2 Demographic and Socio-economic Characteristics of Vegetable Farmers

This section provides an analysis of the demographic and socio-economic characteristics of the sampled 200 farm households, 50 wholesalers and 50 retailers from five villages Galapo, Babati town, Matufa, Bermi and Seloto of Babati district in Manyara region.

Results show that the average household size of vegetable farmers was 6 members compared to that of wholesaler and retailer based households whose average was 5 members. The results on household size were significantly different at 10% significance level (Table 3). These household sizes are higher than majority of agricultural households in the country which have 4 to 5 members (Anderson *et al.,* 2016). The bigger household size for farmers could be due to the need of family labour for on-farm labour since vegetable farming is comparatively more labour intensive than trading in vegetables. Household size is quite important for vegetable farming and agricultural production in general than for off-farm occupations at the community level at large. Thus, having a substantial number of people within a household helps with on-farm family labour and this can substantially affect household cash flows. Alene *et al.* (2008) noted that household size could explain the family labour supply for production activities and household composition levels. This is also consistent with work done by Tufa *et al.* (2014) who found out that the average household size in Ethiopia's farming households was 6; however, it had significant negative influence on commercialization of horticultural crops due to the increased need to meet food requirements for the household. Similar findings were reported by Ansah and Tetteh (2016) who found out that larger household had more incidences of yam post-harvest losses and lower quality of stored food in Ghana. However, Ansah and Tetteh (2016) argue that this argument was counterintuitive since it was expected that larger households should have more labour to handle post-harvest handling activities.

Table 3: Socio-economic characteristics of farmers, wholesalers and retailers

Variable	Farmers	Wholesalers	Retailers	Overall	F/Value
Household size	5.85	5	5.26	5.61	2.067*
Education level	7.08	8.04	6.76	7.19	2.141*
Vegetable farming experience	8.15	7.86	6.20	7.78	1.239
Land size	3.20	2.54	1.82	2.8	2.557*
Vegetable land size (acre)	0.78	0.59	0.44	0.67	2.048*
Distance to market (km)	3.62	5.72	2.69	3.81	2.303*
Number of observations (n)	200				

*: Significant at 10% level

Number of observations = 200 farmers, 50 wholesalers and 50 retailers

Results in Table 3 show that on average farmers had a larger land size (3.20 acres) than wholesalers (2.54 acres) and retailers (1.82 acres) who were also involved in farming. This is within the national averages where smallholders own less than 8.6 acres (Anderson *et al.*, 2016). The differences in land sizes could be attributed to the fact that farmers need relatively bigger land to practice their economic activities (like growing crops) as compared to retailers and wholesalers who may only need smaller portions of land to run their commercial enterprises. On the other hand, land allocated for vegetable production was on the average 0.67 acres for the overall sample. Farmers, wholesalers and retailers had allocated 0.59, 0.78 and 0.44 acres for vegetable production, respectively (Table 3). The results were found to be significantly different across farmers, wholesale and retailers. This implies that smallholder vegetable production was not sufficient in accruing the desired levels of investment that can successfully address post-harvest losses incurred and also participate in formal and high value market. Sanga and Mgimba (2016) concluded that small-scale farmers (operating on < 1 acre) experienced post-harvest losses resulting to marketing challenges thereby making it difficult to explore full market potentials. Small pieces of land also tend to reduce incentives of participation in formal or high-value markets. Additionally, small farm size was noted to also hinder smallholder farmers from participation in high value markets due to limited ability to supply larger volume, consistent quality, time deliveries and standard requirements of high value market (Shipman *et al.*, 2009).

Results in Table 3 further show that farmers had attained on average 7 years of education, while wholesalers had 8 years and retailers 7 years. This shows that all studied categories of agents involved in vegetable production and marketing had attained primary education showed by an average 7 years of schooling. However, about 4% of sampled population had not attended school at all. A probable explanation for this could be that literate farmers more likely to adopt new technologies and crops, can be trained easily and improve on their farm production and post-harvest handling practices for higher yields, minimizing losses and profit maximization. Literate farmers are likely to adopt new technologies than farmers without formal education thereby increasing their productivity and net farm returns (Botlhoko and Oladele, 2013).

In terms of experience in vegetable farming, the results indicate that the respondents had an average 7.78 years of experience in vegetable farming. This shows that most farmers in the study area ventured into vegetable farming less than 10 years ago. This shows that commercial vegetable farming was relatively a new venture among farmers in Tanzania. These results are similar to those observed by Adepoju (2014) who found out that majority of horticultural farmers in Osun State in Nigeria had less than 10 years of farming experience. Sanga and Mgimba (2016) also found that 78.9% of their sampled farmers have less than 20 years' experience in farming.

Farmers sell their vegetable produce to markets where the average distance to the markets is 3.62 kilometres. On the other hand, wholesalers sell their vegetable produce to markets where the average distance to the markets is 5.72. Retailers outsource vegetables for selling at an average distance of 2.69 kilometres and sell them along roadsides and nearby centres. The difference in distance to nearest market was found to be statistically significant across farmers, wholesalers and retailers. The plausible explanation for this could be that farms need to be near local markets where they sell most of their produce due to inability to process their vegetable produce in order to reduce post-harvest losses and lack of capital to access distant markets for higher profit margin. Additionally, retailers are also relatively nearer the markets because they source their merchandise in small quantities from farmers in the locality to cut on transport cost unlike wholesalers who can buy in bulk from distant suppliers. Good physical infrastructure such as good roads is therefore a prerequisite to market access.

Table 4 shows a comparison of categorical socio-economic characteristics of smallholder farmers who are involved in vegetable farming. The socio-economic characteristics discussed here are gender and age of the household head.

Table 4: Socio-economic characteristics (in percentages) of farmers, wholesalers and retailers involved in vegetable farming

Variable	Category	Farmers'	Wholesalers	Retailers	Overall	χ^2
Household members age	between 18-60 years	2.83	2.46	2.72	2.75	0.739
Gender of household head	Female	16	18	48	21	25.573***
	Male	84	82	52	79	

***: Significant at 1% level

Number of respondents = 200 farmers, 50 wholesalers and 50 retailers

Households' members who were aged between 18-60 years were on average 3 members for farmers' and retailers' households and 2 members at wholesalers' households as indicated in Table 4. This could be because age was an important feature in vegetable production and marketing because the activities involved in its production to marketing are fairly tedious and labour intensive in nature. All sampled households in this study used family labour in vegetable farming. These results are consistent with those of Covarrubias (2012) who found that households consist of an average of 5.4 members, 2.5 of which are of working age, defined as being from 15 to 60 years old.

Further results in Table 4 show that, 79 percent of the sampled households were male headed while 21 percent were female headed households. In relation to wholesalers, 82 percent of the households were male headed households while female headed households were 18 percent. Unlike for farmers and wholesalers where male headed households were majority, the results were relatively equal in number of male and female headed households for the retailers where 52% were male and 48% were female. This implies that retail business was not a preserve of either gender; both males and females have commercial orientation when it comes to retailing agricultural products. The Chi-square computation showed a statistically significant difference across gender and involvement in vegetable farming at 1 percent level across the three groups. This is an indication that most agricultural households are male headed and majority of the people who control resources in the households are male. This shows that men were relatively playing a bigger role in managing agricultural enterprises and farm business decision making; however, women's supporting role cannot be overlooked. Adoco and Levine (2005) argue that where both men and women are involved in household decision making, men possess higher authority to use, sell and control many other factors of agricultural production as compared to women.

4.3 Vegetable production and utilization

Different varieties of vegetables were being cultivated in Babati which include African eggplant, tomatoes, cabbages, onions, Chinese cabbages, spinach, eggplant, carrots, okra and chillies. It was also noted that indigenous vegetables (IVs) such as Amaranth, African nightshade, pumpkin leaves and cowpeas leaves were also grown and consumed in Babati. Results show that for the sampled households', farmers produce about 3.8 tonnes of tomatoes per acre per season. The farmers sell their vegetables produce mainly to traders who come to the farm and occasionally farmers who are nearer to urban markets take vegetable straight to the markets. African Eggplant, Amaranth and Tomatoes are consumed in small quantities at household level (less than 6%) because vegetables are mainly added to food to give it a good taste and are rarely used as main sauce (Table 5).

Table 5: Vegetable produced in percent and its utilization along the supply chain

Crop	Utilization	Farm level	Wholesaler	Retail
African Egg-plant	Sold	73	72	51
	Food.	6	2	4
	Other purpose	5	7	4
	Lost	16	19	41
Amaranth	Sold	52	62	58
	Food.	3	3	6
	Other purpose	14	28	24
	Lost	31	7	12
Tomatoes	Sold	49	53	46
	Food.	3	3	4
	Other purpose	17	18	10
	Lost	31	26	40

Number of respondents = 200 farmers, 50 wholesalers and 50 retailers

4.4 Institutional and Market Characteristics in Vegetable Farming

The institutional and market characteristics analysed were: mode of transportation, nature or type of the road, packaging materials and storage condition. Different modes of transportation were used to transport vegetables to the market such as head, bicycle, motorbike, ox cart, car and truck (Table 6).

Table 6: Marketing and market access characteristics (in percentages) of farmers, wholesalers and retailers involved in vegetable farming

Variable	Category	Farmers'	Wholesalers	Retailers	Overall	χ^2
Mode of transportation used	Head	9	8	20	10.7	7.415
	Bicycle	28	26	24	27	3.611
	Motorcycle	25.5	40	46	31.3	12.041***
	Oxcart	3	2	0	2	4.765
	Car	7.5	16.6	2	8	9.874**
	Truck	1	2	0	1	4.072
		26	5	8	20	
Nature/type of the road	Weather	53	64	82	58	
	Murram	21	4	4	16	21.872***
	Tarmac	26	32	14	26	
Packaging materials	Plastic bag	10	14	10	12	31.283***
	Bamboo basket	5	4	16	8	
	Wooden crates	55	72	55	60	
	plastic crates	5	0	2	6	
	Polythine bag	6	0	10	6	
		19	10	7	8	
Storage condition	Normal temperature	99	94	94	96	6.283
	Controlled temperature	1	6	6	4	

***, **: Significant at 1%; and 5% level, respectively

Number of respondents = 200 farmers, 50 wholesalers and 50 retailers

Farmers used bicycles and motorbikes more in transporting their vegetables. From the results 28% of the respondents used bicycles to transport vegetables to the market while 25 percent used motor cycles (Table 6). On the other hand, 26% of the wholesalers transported vegetables using bicycles while 40% used motor cycles. For the retailers, 20% transported vegetables on their heads, 24 percent used bicycles and 46 percent used motor cycles to transport vegetables to the market. The Chi-square results showed that there was a significant relationship between the use of motorcycle at 1% and use of cars at 5% significance level across farmers, wholesalers and retailers. The use of motorcycle could be attributed to it's being relatively cheaper, faster and flexible especially where one needs to transport small loads over short distances. The use of cars could be attributed to the need to transport relatively larger loads as an individual or bulked for a number of people making them relatively more convenient than motorcycles in such scenarios.

Table 6 shows that there was a significant association between the nature of roads used and the types of market participants in vegetable business in Babati. Retailers mainly used all weather roads (83%) while most wholesalers used tarmac roads (64%). The better access to tarmac roads mainly for wholesalers could be because they may tend to travel to big towns to procure or sell their vegetables. Farmers basically used all weather roads (53%) and murram roads (26%). This could be because farmers mainly operate within rural areas where the roads are mainly all weather and murram.

In relation to storage, only 20% of the respondents stored their vegetables under controlled temperature conditions. Majority (over 80%) of the respondents stored their vegetables under normal temperature conditions. This was not statistically different for farmers, retailers and wholesalers. This could be because most of these participants were not able to afford refrigerated storage equipment and cold room facilities. Additionally, the perceived economic benefits of investing in such facilities and equipment could be a disincentive because most of them deal with small quantities of vegetables.

Packaging materials used for handling vegetables were plastic bags, bamboo baskets, wooden crates, plastic crates and polythene bags. Most of the wholesalers (72%) used wooden crates for packaging while 50% of both farmers and retailers used wooden crates for packaging. Tomatoes were packed in large (average of 40-50kg) wooden crates during transportation while African Eggplant and Amaranth were packed in polythene or plastic bags. The wooden crates were unable to provide protection to tomatoes due to its nature (rough and large) hence some of the tomatoes at the bottom of the crates were crushed and discarded before sale. About 19% of farmers, 10% of wholesalers and 4% retailers did not package their produce. These results are similar to those reported by Kitinoja and Al (2012) that 8% of fresh vegetables were not packed and 31% of fresh produce were packed in open baskets. A similar scenario was reported by Adepoju (2014) who found out that tomato farmers in Nigeria transported their produce in open baskets on top of each other. Poor packaging could aggravate post-harvest losses due to the perishable nature and high moisture content of vegetables.

4.5 The quantification of vegetable post-harvest losses

Farmers lost 16.43% of African eggplant, 31.01% of amaranth and 31.77% of tomatoes produce due to different factors (Table 7). These losses could be attributed to field pests and diseases and poor storage. 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. These results are in line with MMA (2008) which 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. Retail market recorded higher vegetables post-harvest losses in which 47.48% of African Eggplant, 12% of amaranth and 35.19% for tomatoes were lost. Such losses at are can be attributed to poor handling practices from farm gate to retail level. The reported high post-harvest losses could be because they are easily noticeable by farmers, traders and consumers. This is because most post-harvest losses are mechanical or damage from pests. This is unlike physiological losses which are mostly associated with diseases and not easily noticeable. This concurs with Adeoye *et al.* (2009) who found out that tomato losses associated with post-harvest losses were higher than physiological losses in Oyo State, Nigeria. 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.

4.5.1 The economic quantification of African egg-plant post-harvest losses

The results of this study (Table 7) show that, farmers incur average losses of 292 kg for African Eggplant per acre per capita per season which is equivalent to TZS 408,800. Moreover, results indicate that wholesalers and retailers incur losses of 77kg and 150 kg of African Eggplant per person per season which is equivalent to TZS 111,650 and 255,000 respectively. The higher losses reported for the farmers could be due to poor post-harvest handling techniques among them, where farmers rarely use cold storage facilities. This could be attributed to poor post-harvest handling skills and limited capital to invest in better storage technologies among farmers as compared to retailers and wholesalers. In general the losses were due to delay in harvesting, long distance to the market, poor roads, mode of transportation, storage condition, pest and diseases. Kereth *et al.* (2013) also found out that rotting (microbial) and poor transportation infrastructure in Bagamoyo, Tanzania accounted for the largest cause of post-harvest losses for horticultural products like fruits. The transport losses in Bagamoyo were attributed by delays in delivery and mechanical damages of fruits during transit. Wholesalers do not incur storage losses in African Eggplant as they transfer the risk to retailers.

Table 7: The average amount (Kilogrammes) of African eggplant lost in the last season (year 2015/2016) and the cause of such losses

	Farmers			Wholesalers			Retailers		
	Quantity (kg)	**Percent**	**Value (TZS)**	**Quantity (kg)**	**Percent**	**Value (TZS)**	**Quantity (kg)**	**Percent**	**Value (TZS)**
Delay in Harvesting	102	34.93	142,800	27	35.06	39,150	30	19.51	45,000
Distance to the market	14	4.79	19,600	-	-	-	-	-	-
Poor road	14	4.79	19,600	5	6.49	7,250	10	5.49	15,000
Mode of transportation	17	5.82	23,800	-	-	-	-	-	-
Pest and diseases	100	34.25	140,000	45	58.44	65,250	90	60.98	135,000
Storage condition	46	15.75	64,400	-	-	-	20	14.02	30,000
Total	**292**	**100.00**	**408,800**	**77**	**100.00**	**111,650**	**150**	**100.00**	**255,000**

Note: Number of respondents = 200 farmers, 50 wholesalers and 50 retailers

Average price = TZS 1,400 farmers, TZS 1,450 wholesalers and TZS 1,500 retailers

4.5.2 The economic quantification of amaranth post-harvest losses

The results of this study (Table 8) show that on average, farmers incur losses of 363 kg of Amaranth per acre per person which is equivalent to TZS 181,500. Also it was found that wholesalers and retailers incur losses of 43 kg and 28 kg of Amaranth per season which is equivalent to TZS 23,650 and 16,800 respectively. These losses are attributed to different factors such as harvesting method, delay in harvesting, loading or off-loading, poor storage condition, pest and diseases. During marketing, harvested Amaranth is stored by spreading on polythene or plastic bags (*viroba*) in order to prevent it from contacting moisture from the ground and in some cases amaranth is exposed to the cold at night. It was observed that retailers lack storage facilities with controlled temperature which leads to lower market value for the stored amaranth.

Most Amaranth traders sell it in an unpackaged form or in tied bundles which if not sold quickly reduces its shelf-life. Adepoju (2014) also argued that with poor storage facilities, poor packaging and inefficient mode of transportation, post-harvest losses in vegetables are inevitable. For example, the market value of a bunch of leafy greens which is wilted is only half of its original price (Kitinoja, 2010). Post-harvest losses in leaf vegetables are estimated to be more than 30% and are generally caused by poor handling and storage condition (Nyaura *et al.*, 2014). An increase in temperature leads to water loss and respiration rates increase, which leads to decline in quality of fresh produce and its market value.

Table 8: The average amount (Kilogrammes) of amaranth lost in the last season (year 2015/2016) and the cause of such losses

	Farmers			Wholesalers			Retailers		
	Quantity (kg)	**Percent**	**Value (TZS)**	**Quantity (kg)**	**Percent**	**Value (TZS)**	**Quantity (kg)**	**Percent**	**Value (TZS)**
Harvesting method	25	6.89	12,500	-	-	-	-	-	-
Delay in Harvesting	229	63.09	114,500	35	81.40	19,250	7	25.00	4,200
Loading/Off loading	68	18.73	34,000	-	-	-	-	-	-
Pest and diseases	25	6.89	12,500	8	18.60	4,400	14	50.00	8,400
Storage condition	15	4.13	7,500	-	-	-	7	25.00	4,200
Total	**363**	**100.00**	**181,500**	**43**	**100.00**	**23,650**	**28**	**100.00**	**16,800**

Note: Number of respondents = 200 farmers, 50 wholesalers and 50 retailers

Average price = TZS 500 farmers, TZS 550 wholesalers and TZS 600 retailers

4.5.3 The economic quantification of tomatoes post-harvest losses

Cultivation and selling of tomatoes is more dominant compared to other vegetables in the study area. The study found out that 80% of farmers cultivated tomatoes while 88% and 96% of wholesalers and retailers sold tomatoes (Table 9). Compared to African eggplant and amaranth, tomato is one of the vegetables most susceptible to post-harvest losses. In relation to post-harvest losses, the results show that about 1.8 tonnes of tomatoes were lost per acre per season per person which is equivalent to TZS 918,500. Additionally, it was found that about 0.4 and 0.5 tonnes are lost by wholesalers and retailers per capita per season and these losses were equivalent to TZS 237,000 and TZS 468,000 at wholesale and at retail level. This concurs with the findings by Sharma and Singh (2011) who found that vegetable post-harvest losses were highest among farmers.

The losses were attributed to different factors such as 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 show that delay in harvesting, pests and diseases were the major contributing factors of postharvest losses at all levels of the supply chain. 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 post-harvest losses faced by farmers in Osun State, Nigeria. Similar findings were reported by Adeoye *et al.* (2009) who found that mechanical damages, physiological and pathological as being the major causes of tomato losses in Oyo State, Nigeria.

Table 9: The average amount (Kilogrammes) of tomatoes lost the last season (year 2015/2016) and the cause of such losses

	Farmers			Wholesalers			Retailers		
	Quantity (kg)	**Percent**	**Value (TZS)**	**Quantity (kg)**	**Percent**	**Value (TZS)**	**Quantity (kg)**	**Percent**	**Value (TZS)**
Harvesting method	73	3.97	36,500	-	-	-	-	-	-
Delay in Harvesting	751	40.88	375,500	87	22.03	52,200	180	38.46	180,000
Loading/Off loading	46	2.50	23,000	-	-	-	-	-	-
Distance to the market	37	2.01	18,500	29	7.34	17,400	9	1.92	9,000
Nature of the road	12	0.65	6,000	-	-	-	-	-	-
Mode of transportation	154	8.38	77,000	-	-	-	-	-	-
Pest and diseases	539	29.34	269,500	114	28.86	68,400	136	29.06	136,000
Storage condition	190	10.34	95,000	164	41.52	98,400	52	11.11	52,000
Packaging materials	36	1.96	18,000	-	-	-	91	19.44	91,000
Total	**1,837**	**100.00**	**918,500**	**395**	**100.00**	**237,000**	**468**	**100.00**	**468,000**

Note: Number of respondents = 200 farmers, 50 wholesalers and 50 retailers

Average price = TZS 550 farmers, TZS 500 wholesalers and TZS 1,000 retailers

The results of this study are also in line with Yeole and Curran (2016) who found that post-harvest losses of tomatoes are due to lack of low cost cold storage facilities and improper packaging techniques at farm level. Additionally, at farm level the post-harvest losses 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 post-harvest losses.

4.6 Principal causal factors contributing to selected vegetable post-harvest losses

The principle causal factors of African eggplant, amaranth and tomato post-harvest losses at farm level, wholesale and retail was analysed using Log linear regression. The analysis was done in different regression models for farmers, wholesalers and retailers. The dependent variable in each of the regression models was the posited post-harvest loss expressed in kilogrammes and converted to its monetary value (TZS) equivalent by multiplying the quantity with the average market price. The value was logged and expressed as $LnAfrPHL$ in the model.

$$LnAfrPHL = \beta_0 + \beta_1 Edu + \beta_2 Farm\exp + \beta_3 Farmsize + \beta_4 Harvetnm + \beta_5 Dharv + \beta_6 Loading + \beta_7 Distmrk + \beta_8 Roadtyp + \beta_9 Trans\text{mod} + \beta_{10} P \& D + \beta_{11} Storage + \beta_{12} Packmat + \varepsilon ....(xiv)$$

The independent variables specified in the regression model include: education level of the farmer, vegetable farming experience, farm size allocated for vegetable production, method of harvesting, delay in harvesting, loading or off-loading, distance to the market, road nature of the road, mode of transportation, pest and diseases, storage condition and packaging. The model fit results for the three types of vegetables are as shown in Table 10, Table 11 and Table 12.

4.6.1 Principal causal factors contributing to post-harvest losses in African eggplant

Pest and diseases is one of the principle causal factors leading to high post-harvest losses for African eggplant for wholesalers, retailers and farmers at 1% significance level (Table 10). Outbreak of pest and diseases increases post-harvest losses by 3, 6 and 7 percent per season to farmers, wholesalers and retailers respectively. This shows that retailers and wholesalers face significantly higher losses on African Eggplant compared to farmers. This could be because most of the responsible pests and diseases attacking the vegetables during storage. Therefore, this affects farmers to a lesser extent as most of them tend to sell immediately after harvest leaving wholesalers and retailers to store for longer periods before selling to their customers. *Phomopsis blight* was common in the last season in which it affected fruits of eggplant, which began as sunken spots that eventually enlarged and became soft and spongy. Pests and diseases could also magnify the losses as some remained active from when the plant is still in farm until long after harvesting.

Table 10: Principal causal factors contributing to post-harvest losses of African Eggplant

	Farmers		Wholesalers		Retailers	
LnAfrEPHL	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Education	0.010	0.038	0.062	0.055	0.057	0.077
Experience	-0.016*	0.011	0.000	0.019	-0.010	0.014
HH size	0.023	0.028	0.000	0.000	-0.001	0.000
Farm size	0.266	0.191	0.623***	0.213	-0.142	0.374
Delay in harvesting / selling	0.022***	0.002	0.054***	0.008	0.092***	0.012
Distance to the market	0.004	0.011	0.006	0.015	0.044	0.057
Nature of the road	0.215	0.174	-0.076	0.269	-	-
Mode of transportation	0.003	0.005	-0.061	0.274	0.123	0.220
Pest and diseases	0.031***	0.003	0.059***	0.009	0.069***	0.007
Storage condition	0.208	0.242	-0.145	0.476	-	-
Packaging materials	0.000	0.000	0.196	0.272	0.032	0.099
_constant	-0.001	0.442	-0.335	0.780	-0.160	0.594

Farmers:	Prob>F=0.000	R-square=0.6316	Adj R-square=0.61	N=200
Wholesalers:	Prob>F=0.000	R-square=0.8388	Adj R-square=0.7921	N=50
Retailers:	Prob>F=0.000	R-square=0.8914	Adj R-square=0.8523	N=50

***, *: Significant at 1% and 10% level, respectively

Delay in harvesting was another principle causal factor contributing to African Eggplant post-harvest losses to farmers, wholesalers and retailers at 1% significance level (Table 10). Losses attributed to delay in harvesting were least at farm level at about 2 percent per season compared to losses at wholesale and retail levels which were 5 and 9 percent per season respectively. This shows that farmers generally harvested their produce on time hence the lower level of losses compared to wholesalers and retailers. The losses were attributed to poor handling during harvesting and lack of suitable storage facilities whereby the farmers left their African eggplant at the field until they got customers to buy them. Additionally, some of the vegetables upon harvesting are left in the open, without a shade, where either the sun scotches them, insects and pathogens attack or the rain makes them muddy. This causes rotting, weight loss and wilting on the vegetables (Sibomana *et al.,* 2016). The bulk of the risk of losses is transferred to wholesalers and retailers who receive and sell the produce a number of days after harvesting.

Growing African eggplant in larger pieces of land increased post-harvest losses among wholesalers at 1% significance level. Growing the vegetables for wholesalers may have added a bigger responsibility to them as they have to monitor their own farms, have additional supplies from their own harvests and still have to source supplies from other sellers. The divided attention and more responsibilities could have led to more losses from their own produce or the quantities they put together to resell on wholesale.

Experience in vegetable farming was found to have negative influence therefore leading to a decrease in post-harvest losses among farmers at 10% significance level. This could be attributed to the number of years a farmer has grown the vegetable where those who have grown it for many years may have tended to have discovered or adopted new ways of reducing post-harvest losses. This is in the case where such farmers learn from experience and avoid making the same mistakes again. Additionally, the older farmers in African eggplant farming could have become entrepreneurial over time where profit maximization took precedence over home consumption.

4.6.2 Principal causal factors contributing to post-harvest losses of Amaranth

Field pests and diseases appeared to be one of the principle causal factors leading to Amaranth post-harvest losses significant at 1% across farmers, wholesalers and retailers (Table 11). Amaranth was disfigured and damaged by several species of small flies that live as maggots between the upper and lower surfaces of the leaves and contributed to post-harvest losses of about 10, 25 and 24 percent per season to farmers, wholesalers and retailers. Gomes *et al.* (2015) argues that physical damage on leafy vegetables favours microbial infections since natural resistance decreases with maturation, therefore favouring invasion by pathogens. The infected amaranth leaves thereafter become unattractive and unfit for human consumption.

Table 11: Principal causal factors contributing to Amaranth post-harvest losses

	Farmers		Wholesalers		Retailers	
LnAmaPHL	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Education	0.022	0.032	-0.021	0.036	-0.035	0.055
Experience	-0.007*	0.009	0.000	0.010	0.021	0.010
HH size	-0.002	0.024	0.000	0.000	0.000	0.000
Farm size	-0.203	0.165	0.130	0.113	0.064	0.261
Harvesting method	-0.056	0.137	-	-	-	-
Delay in harvesting/ selling	0.014***	0.001	0.067***	0.007	0.276*	0.138
Loading/Off loading	-0.390	0.944	-	-	-	-
Distance to the market	-0.017	0.009	-0.002	0.008	-0.017	0.038
Nature of the road	-0.228	0.148	0.008	0.159	-	-
Mode of transportation	-0.003	0.004	0.120	0.157	-0.227	0.158
Pest and diseases	0.108***	0.013	0.252***	0.029	0.241***	0.028
Storage condition	-0.032	0.208	-0.187	0.276	-	-
Packaging materials	0.000	0.000	0.031	0.155	0.028	0.072
_constant	0.667**	0.378	0.285	0.479	0.251	0.447

Farmers:	Prob>F=0.000	R-square=0.8029	Adj R-square=0.7458	N=200
Wholesalers:	Prob>F=0.000	R-square=0.8646	Adj R-square=0.8254	N=50
Retailers:	Prob>F=0.000	R-square=0.8172	Adj R-square=0.7514	N=50

***, **, *: Significant at 1%; 5% and 10% level, respectively

Delay in harvesting was also the other principle causal factor contributing to amaranth post-harvest losses significant at 1% for farmers. Delay in harvesting contributed to losses of about 1 percent per season at farm level. The losses were attributed to lack of cropping calendar and poor timing of the market. Delays in harvesting led to moisture loss and wilting of the vegetables leading to loss in quality while still in the field. On the other hand, delay in selling was also a principle causal factor contributing to amaranth post-harvest losses significant at 1% for wholesalers and 10% for retailers (Table 11). Delay in selling contributed to losses of about 7 and 3 percent for wholesale and retail respectively. These losses may be attributed to incidences where the sellers had to store the vegetables for a few days before selling.

4.6.3 Principal causal factors contributing to post-harvest losses of tomatoes

Pest and diseases is the one of the principle causal factor leading to high post-harvest losses significant at 1% to farmers and wholesalers and 5% to retailers (Table 12). Outbreak of pest especial tomato leave miner (*Tuta absoluta)* increases post-harvest losses by 3, 1 and 8 percent per season to farmers, wholesalers and retailers respectively. Tomato leaf miner can cause 50-100% yield reduction on tomato crops and its presence may also limit the export of the product to several destinations (Koppert, 2009). This concurs with Kereth *et al.* (2013) who found out that microbial (pest and diseases) significantly influenced post-harvest losses especially during marketing of tomatoes.

Delay in harvesting was also another principle causal factor contributing to Tomato post-harvest losses significant at 1% at farm level. Delay in harvesting contributed to losses of about 3 percent per season per farmer. The delays in harvesting could be because farmers tend to look for markets when the crop is already mature and therefore it ends up being delayed further in the farm before harvest. At times, some farmers also tend to sell their crop before maturity to tap into an immediate market demand or due to urgent need for cash. Given that maturity at harvest is one of the most important factors that determine shelf life and final vegetable quality. In a study of the tomato supply chain in Ethiopia Emana *et al.* (2017) also found significant tomato losses being associated with delays in harvesting. This concurs with Sharma and Singh (2011) who also concluded that tomatoes picked too early or too late in their season are more susceptible to post-harvest physiological disorders leading to irregular ripening and poor quality.

Higher losses are often associated with higher amount of harvest resulting from relative bigger land size under production. As a result farmers with relatively bigger plots were more likely to get more losses of about 46.09 kg per acre.

Table 12: Principal causal factors contributing to post-harvest losses in Tomato

	Farmers		Wholesalers		Retailers	
lnTomPHL	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	Coef.	Std. Err.
Education	0.028	0.066	-0.067	0.103	0.035	0.178
Experience	0.011	0.018	-0.021	0.036	-0.019	0.036
HH size	-0.008	0.050	0.000	0.001	-0.001	0.001
Farm size	0.133	0.332	0.010	0.354	1.454	0.865
Harvesting method	-0.133	0.287	-	-	-	-
Delay in harvesting	0.03***	0.001	0.005	0.007	0.008	0.006
Loading/Off loading	-0.017	0.034	-	-	-	-
Distance to the market	0.031	0.019	0.041	0.027	-0.046	0.130
Nature of the road	-0.434	0.311	-0.711	0.513	-	-
Mode of transportation	-0.009	0.008	0.637	0.510	0.502	0.652
Pest and diseases	0.03***	0.000	0.012***	0.003	0.08**	0.003
Storage condition	0.718*	0.435	-1.226	0.925	-	-
Packaging materials	0.000	0.000	0.270	0.509	0.215	0.247
_cons	2.590***	0.801	4.102	1.468	1.960	1.402

Farmers:	Prob>F=0.000	R-square=0.4425	Adj R-square=0.4036	N=200
Wholesalers:	Prob>F=0.000	R-square=0.5836	Adj R-square=0.4631	N=50
Retailers:	Prob>F=0.0027	R-square=0.5930	Adj R-square=0.4465	N=50

***, **, *: Significant at 1%; 5% and 10% level, respectively

Lack of storage facilities to control temperature on matured tomatoes increases tomatoes post-harvest losses among farmers at 1% significance level. This could be because tomatoes have a short shelf life at room temperature and worse if the temperature is higher. Lack of awareness among farmers about the right temperatures to store tomatoes could also be a contributing factor. In a review of post-harvest losses in tomatoes in Sub-Saharan Africa (SSA) Sibomana *et al.* (2016) concluded that lack of awareness on required quality standards aggravated post-harvest losses especially among smallholder farmers. Additionally, farmers, retailers and wholesalers mostly used wooded crates for transport and storage during marketing of tomatoes. Such crates could be rough and with spikes that pierce the tomatoes causing physical damage to the tomatoes while also creating entry points for pathogens which further damage the tomatoes. The damage while in the crates was aggravated where the tomatoes were transported using motorbikes on rough roads. This shook the tomatoes and scratched them further on the rough internal surface of the wooded boxes used during transit.

To sum up, tomatoes had the highest post-harvest losses (18370kg) compared to African egg-plant (395kg) and amaranth (468kg). This could be attributed to its delicate coat cover, high water content, short shelf-life and poor handling during transport and marketing. Similar findings were reported by Sharma and Singh (2011) where tomatoes were reported to have the highest post-harvest losses compared to other vegetables like capsicum, French beans, cabbages, onions, potato and chilly in Uttarakhand, India. Pest and diseases, and delays in harvesting accounted for the greatest post-harvest losses in the studied vegetables. This concurs with Gomes *et al.*(2015) and Emana *et al.* (2017) who also concluded that pest and diseases aggravated post-harvest losses in vegetables and fruits which occurred during transportation, storage and marketing.

4.7 Factors influencing farmers' choice of post-harvest handling practices and techniques for African eggplant, amaranth and tomato

Table 13 presents results of the Multivariate Probit Model on the factors influencing farmers' choice of post-harvest handling techniques and practices. The dependent variable used was farmers' post-harvest handling techniques which was categorical in nature. The categories of these techniques were: maturity indices, shade, sorting or grading, washing or hygiene and cooling. The independent variables used in the model were age (years), education levels (years), farming experience in vegetable production (years), farm size allocated to vegetable cultivation (acres), quantity of vegetable harvested (kg), household income, vegetable price, access to extension services on post-harvest losses, household size. The Wald Chi-square value of 98.89 ($P<0.01$) showed that the likelihood ratio statistics are significant suggesting that predicators included in the model were capable of jointly predicting and explaining choice of post-harvest handling techniques and practice.

Table 13: Factors influencing farmers choice of post-harvest handling technique and practice for African eggplant, amaranth and tomato

	Maturity Indices		Shade		Sorting		Washing/Hygiene		Cooling	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Age	-0.008	0.051	0.037	0.044	0.045	0.045	0.096	0.036	-0.026	0.047
Education Level	0.000	0.054	0.013**	0.045	0.030	0.043	-0.047	0.046	-0.093**	0.043
Experience	-0.005	0.016	-0.005	0.015	0.012	0.014	0.018	0.015	0.005	0.014
Farm size	0.207	0.269	0.376*	0.220	0.499**	0.230	0.241	0.207	-0.235	0.243
Harvest Egg plant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000*	0.000
Harvest Amaranth	0.001*	0.000	0.000	0.000	0.001*	0.000	0.001*	0.000	0.001*	0.000
Harvest Tomato	0.001*	0.000	0.000	0.000	0.000	0.000	0.001*	0.000	0.000	0.000
Ln HH. income	-0.252**	0.128	-0.355***	0.099	-0.193**	0.090	-0.345***	0.100	0.257**	0.116
HH. Size	0.016	0.040	-0.018	0.038	0.065	0.037	-0.047	0.031	0.035	0.036
Age square	0.000	0.001	0.000	0.001	0.000	0.001	-0.001	0.000	0.000	0.001
Extension	0.515**	0.218	0.395**	0.181	0.424**	0.177	0.304*	0.184	0.099	0.206
Constant	3.390*	1.764	3.237**	1.318	0.472	1.315	2.663*	1.414	-2.863*	1.708

Note: *, **, *:** Significant at 1%; 5% and 10% level, respectively
Multivariate probit (SML, # draws = 5); Number of respondent. = 200; Wald chi2(55) = 98.89;
Log likelihood = -364.19776; Prob > chi2 = 0.0003; Prob > chi2 = 0.0000

An increase in the level of education by one year reduces the probability of choosing cooling as a post-harvest handling technique by 9.3% at 5% significance level. However, an increase in the level of education by one year increases the probability of choosing shade as a post-harvest handling technique by 1.3% at 5% significance level. This differs from an earlier study by Okoruwa *et al.* (2009) who found out that a percentage increase in years of education increased the odds of using local and modern storage techniques in post-harvest produce management. The difference in findings could be because cooling requires higher capital costs like freezers or refrigerated containers as compared to storing the vegetables under shades. Therefore, even more educated farmers in Babati District opted to go for shades due to the higher financial implications associated with cooling.

Increase in farm size by one acre increases the probability of adopting washing or hygiene as a post-harvest handling technique and practice by 37.6% at 10% significance level. On the other hand, one acre increase in farm size increases the probability of choosing sorting as a post-harvest handling technique by 49.9% at 5% significance level. The possible explanation for this could be because quantity harvested and variable cost increases with land size under cultivation. Therefore, a farmer would prefer to minimize post-harvest losses in order to earn more revenue. For a relatively larger land size under cultivation of a given vegetable, the harvester would have to sort, collect and provide shade for the heaps of produce within and outside the farm. This translates to more labour costs to handle more vegetables.

Quantity of vegetable harvested is also a significant determinant of the choice of post-harvest handling techniques and practices. Increase in quantity of African eggplant, amaranth and tomato harvested by one Kg increased the probability of adopting maturity indices, sorting or grading, washing or hygiene and cooling by about 0.1% at 1% significance level. The results reflect the important role quantities harvested plays in influencing farmers' adoption decisions. As quantities harvested increase, farmers increase the diversity of post-harvest handling techniques they chose to adopt to preserve their produce. This shows that farmers prefer to spread risks rather than relying on only one option especially when larger amounts of returns from their vegetable or other agricultural enterprises are involved. The results concur with the findings of Okoruwa *et al.* (2009) that increase in quantity of stored produce had significant and positive influence on farmers' choice of local storage techniques like local cribs, platform, rhombus, roof and fireplace and semi-modern storage techniques like ventilated cribs and improved rhombus in South-West Nigeria.

Decrease in the level of household income by one TZS reduced the probability adopting of maturity indices by 25.2%, shade by 35.5% and washing or hygiene by 19.3% post-harvest handling techniques and practices at 5%, 1% and 1% significance levels respectively. The results imply that maturity indices, shade and washing or hygiene are more common among the low income earners. This implies that as income increases the farmers tend to shift to other advanced practices like cooling, sorting and grading which they consider more effective even though they have to spend more money on these practices. This is in line with Ali (2012) who concluded that more income and use of credit influenced farmers to adopt modern post-harvest handling techniques in vegetable value chain. Kiaya (2014) argues that harvesting and storage hygiene is a simple practice with minor financial implications for smallholder farmers with limited post-harvest handling options to choose from due to financial constraints. Similarly, Muzari *et al.* (2012) concluded that farmers' and other actors in agricultural marketing chains income levels influence adoption of agricultural technologies since most technologies require money to adopt and they divert a considerable amount of income from other important household activities.

The results indicate that increase in farmers' access to extension services increased the probability of adopting maturity indices, shade and sorting as post-harvest handling techniques and practices by 51.5%, 39.5% and 42.4% respectively at 5% significance level while probability of adopting washing or hygiene increased by 30.4% at 10% significance level. This implies that, for farmers to choose either to adopt maturity indices, shade, sorting or to wash their after harvesting and storage of their produce, they require appropriate training to acquire the right skills and regular reminding of the importance of doing so. Mariano *et al.* (2012) underscore the importance of extension by concluding that extension related variables like attendance to trainings, access to extension workers and participation in on-farm demonstrations had the highest impact on technology adoption in agricultural related activities.

Generally, this study concurs with Kiaya (2014) that there are a number of different technologies that that can easily be adopted by farmers and market participants to reduce post-harvest losses. Post-harvest handling techniques such as maturity indices to identify proper harvesting time, improved containers to protect produce from damage during handling and transportation, use of shade and sorting or grading to enhance the shelf-life and market value were generally practiced locally. 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. Sanitation and maintaining good hygiene was practiced during harvesting and storage to maintain produce quality. This concurs with Waliyar *et al.* (2015) who recommended field and storage sanitation as a good agricultural practice.

This study found out that decision of washing vegetables was influenced by household income, land size allocated for vegetable production, access to extension services and quantity of vegetables harvested. On the other hand, the choice of using shades was influenced by education level of the farmer, household income and quantity of vegetables harvested. The choice maturity indices were influenced by household income and quantity of vegetables harvested. Moreover, the choice of cooling during storage was influenced by education level of the farmer and quantity harvested while sorting or grading is only influenced by the quantity harvested.

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 pot-harvest handling technique based on its efficiency and ability to enhance a crop's shelf-life. Similarly, the post-harvest handling choices identified in Babati, Tanzania were mainly helped reduce vegetable losses and lengthen shelf-life.

CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Post-harvest losses in selected vegetables were estimated to constitute up to 40% of the harvest. The economic postharvest losses incurred per individual per season for Egg-plant were TZS 408,800, TZS 111,650 and TZS 255,000; Amaranth TZS 181,500, TZS 23,650 and TZS 16,800 and Tomatoes TZS 918,500, TZS 237,000 and TZS 182,100 for farmers, retailers and wholesalers respectively. These losses are not only significant but also troubling to the vegetable supply chain actors. Given low output from smallholder farmers, the losses tend to exacerbate the problem of low agro-incomes. Generally, post-harvest loses were linked to a weak commercial orientation especially among the farmers whose marketable surplus was little. Additionally, there was a low use of appropriate storage facilities across the vegetable supply chain.

5.2 Conclusion

1. Retailers recorded higher proportion of vegetables post-harvest losses compared to farmers and wholesalers.

2. The post-harvest losses were significantly intensified by delays in harvesting, pest and diseases at farm level. While delay in selling and field pest were the significant causes of vegetable post-harvest losses at retail and wholesale levels.

3. Quantity harvested, education level and access to extension services had significant positive influence on choice of post-harvest handling techniques while household income and farm-size had significant negative influence.

5.3 Recommendations

1. Facilitate access to equipped storage facilities among the supply chain actors.

2. There is need for training to farmers on timely harvesting, and field pest and diseases control measures.

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.

5.4 Suggestions for further research

This study only focused on African eggplant, amaranth and tomatoes at farm level, wholesale and retail despite the fact that there are many species of vegetables and several other marketing nodes. Further studies can be conducted on other vegetables and marketing nodes not covered in this research. 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.

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APPENDIX

Questionnaires

QUESTIONNAIRE FOR ECONOMIC COST QUANTIFICATION OF SELECTED VEGETABLES POSTHARVEST LOSSES IN BABATI DISTRICT TANZANIA (farmers)

Questionnaire Number [ ]

Enumerator name: ___________________________	Date: ________________________________	
A1	Name of the respondent:	
A2	Tel. no:	
A3	District: **BABATI**	
A4	Town/Village: _____________	Gallapo = 1; Matufa = 2; Bermi = 3; Seloto = 4
A5	Sex of household head? _____	Female = 0; Male = 1
A6	Type of the household ____	1=Nuclear, 2=Extended, 3= Polygamous, 4=De jure female headed (widow, never married, divorced), 5=De facto female headed (husband absent), 6= not yet married males; 999= Do not know/Missing
	Demographic data respondent:	
A7	Position of respondent: _________	1= H/Head ; 2= Wife; 3= Child; 4=Relative
A8	Sex: ______	
A9	Age (years): ______	
A10	Educational Level (years): ________	0 = Female 1 = Male;
A11	Farming Experience in Veg. Production (years) ______	
A12	Marital Status _______	1= Married 2 = Single 3 = Divorced 4 = Separated 5.Widowed

A13	Major Occupation ______	1= Farming 2=Salaried Employee 3= Hired worker
A14 A15 A16 A17 A18	*If there is a partner in the household, fill out:* Position of respondent: _________ Sex: ______ Age (years): ______ Educational Level (years): ________ Farming Experience in Veg. Production (years) _____	1= H/Head ; 2= Wife; 3= Child; 4=Relative 0 = Female 1 = Male;
A19	Marital Status _______	1= Married 2 = Single 3 = Divorced 4 = Separated
A20	Major Occupation ______	1= Farming 2=Salaried Employee 3= Hired worker
A21 A22 A23 A25	What is the household size and gender composition? Total: _____ Men (adult): ______ Women (Adult): ______ Children (under 18) ______	
A26 A27 A28	What is the household's age structure? 0 – under 18 years: _______ 18 - 60 years: _______ Above 60: ________	
A29 A30 A31	What is the household's average income category per month? Total: ______ Husband: ______ Wife: _______ Other: _______ (if other please specify): ……………………..	

B: VEGETABLE PRODUCTION AND FARMING DECISION		
		1= Making Profits 2 = Support the family;

B1	What is your major objective in vegetable production? (tick the appropriate one): _____	3 = Reduce risk of hunger; 4 = As a way of life; 5 = Have no other option (could abandon farming) ; 6 = Others ***999 = I don't know/missing***
	If other, please specify: ________________________	
B2	What is your total land endowment? _________acres.	***999 = I don't know/missing***
B3	What farm size allocated to vegetable cultivation? ______acres.	***999 = I don't know/missing***
B4	How is that land owned? _________	1= Owned ; 2= Rented ; 3=Borrowed; ***999 =I don't know/Missing***
 B5 B6 B7 B8 B9 B10 B11 B12 B13	Who in the household decides on; Land use decision? ___________ Production decision? ____________________ Produces the vegetable? (actively works on farm)___ Income from vegetable production? ______________ Utilisation of vegetable produce? _____________ How the vegetable produce is stored? ___________ How the vegetable produce is marketed? _________ In charge of the timing of the marketing? _________ Carrying out the actual selling of produce? ________	1 = Husband; 2 = Wife; 3= Both (Husband and Wife) 4 = Husband, Wife and Children 99***9 = I don't know/ Missing***
 B14 B15 B16 B17	What is the division of responsibility in African Eggplant; Production: ___________ Other, please specify:___________ Harvesting: ___________ Other, please specify: ___________ Post-harvest handling: _____________ Other, please specify: ____________ Marketing: ___________ Other, please specify: ___________	1 = Husband; 2 = Wife; 3= Both 4 = Others 999 = I don't know/ Missing
 B18	What is the division of responsibility in Amaranth; Production: ____________	

 B19 B20 B21	Other, please specify:___________ Harvesting: ___________ Other, please specify: __________ Post-harvest handling: ____________ Other, please specify: ___________ Marketing: ___________ Other, please specify: __________		1 = Husband; 2 = Wife; 3= Both 4 = Other 999 = I don't know/ Missing
 B22 B23 B24 B25	What is the division of responsibility in Tomatoes; Production: ___________ Other, please specify:___________ Harvesting: ___________ Other, please specify: __________ Post-harvest handling: ____________ Other, please specify: ___________ Marketing: ___________ Other, please specify: __________		1 = Husband; 2 = Wife; 3= Both 4 = Other 999 = I don't know/ Missing
  B26 B27 B28	Does the household have the access of extension services in vegetable: Production: ________ Post-harvest handling: _______ Marketing: _______		0 = No 1 = Yes
  B29 B30 B31	Who in the household have the access to extension services in vegetable Production: _____________ Post-harvest handling: _______________ Marketing: _______________		1 = Husband; 2 = Wife 3 = Both (Husband and Wife) 4 = Relatives 999 = I don't know/ Missing
 B32 B33 B34	What type of seed did you plant at the last season? African Eggplant: _____________ Amaranth: ____________ Tomatoes: ____________		1 = Improved; 2 = Not improved
 B35 B36 B37	How much (in average) did you harvest per season? African Eggplant; ___________Kg Amaranth; ________________Kg Tomatoes; ______________Kg	 B38 B39 B40	How much did you sell per season? African Eggplant; ___________Kg Amaranth; ________________Kg Tomatoes; ______________Kg

<table>
<tr><td>B41
B42
B43</td><td>How many (Kg) of vegetable produce used as a food?
African Eggplant:_______________
Amaranths: _______________
Tomatoes: ________________</td><td>B44
B45
B46</td><td>What % used as food?
African Eggplant:_______________%
Amaranths: ______________%
Tomatoes: _______________%</td></tr>
<tr><td>B47
B48
B49</td><td>How many Kg of vegetable produce used for other purposes?
African Eggplant:_____________________
Amaranths: _____________________
Tomatoes: ________________</td><td>B50
B51
B52</td><td>What % used for other purposes?
African Eggplant:_______________%
Amaranths: ______________%
Tomatoes: _______________%</td></tr>
<tr><td>B53
B54
B55</td><td colspan="2">How do you harvest your produce?
African Eggplant; ___________
Amaranth; ____________
Tomatoes; ____________</td><td>1 = Harvested manual
2 = Harvested with scissor
3= Knife</td></tr>
<tr><td>B56</td><td colspan="2">Do you harvest all vegetable at the one time?
_______________</td><td>0 = No 1 = Yes</td></tr>
</table>

<table>
<tr><td>B57
B58
B59
B60
B61
B62
B63
B64
B65
B66
B67
B68
B69
B70
B71</td><td>What is/are the factors contributing to post-harvest losses in vegetables? 0 = No 1 = Yes
Education level: __________
Experience in Veg. farming: _________
Farm size: _______________________
Harvesting method: ______________
Time of harvesting: ______________
Loading/Off-loading: ____________
Distance to the market: ___________
Nature of the road: ______________
Mode of transportation: __________
Contamination: ________________
Storage condition: ______________
Packaging materials: ____________
Financial Constraints: ______________
Labor Constraints: ______________
Gender of the responsible person: _____________</td><td>B72
B73
B74
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B84
B85
B86</td><td>If Yes/No;
Give reason
____
____
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____
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___________________________________</td></tr>
</table>

B87 B88 B89 B90 B91 B92 B93 B94 B95	How much is lost (African Eggplanta0 due to the following reason? Harvesting method: ____________Kg Time of harvesting: ____________Kg Loading/Off-loading: ___________Kg Distance to the market: ___________Kg Nature of the road: ______________Kg Mode of transportation: __________Kg Contamination: ________________Kg Storage condition: ______________Kg Packaging materials: ____________Kg	B96 B97 B98 B99 B100 B101 B102 B103 B104	Value of the loss in Tsh ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________
B105 B106 B107 B108 B109 B110 B111 B112 B113	How much is lost (Amaranth) due to the following reason? Harvesting method: ____________Kg Time of harvesting: ____________Kg Loading/Off-loading: ___________Kg Distance to the market: __________Kg Nature of the road: _____________Kg Mode of transportation: _________Kg Contamination: _______________Kg Storage condition: _____________Kg Packaging materials: ___________Kg	B114 B115 B116 B117 B118 B119 B120 B121 B122	Value of the loss in Tsh ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________
B123 B124 B125 B126 B127 B128 B129 B130 B131	How much is lost (Tomatoes) due to the following reason? Harvesting method: ____________Kg Time of harvesting: ____________Kg Loading/Off-loading: ___________Kg Distance to the market: _________Kg Nature of the road: _____________Kg Mode of transportation: _________Kg Contamination: _______________Kg Storage condition: _____________Kg Packaging materials: ___________Kg	B132 B133 B134 B135 B136 B137 B138 B139 B140	Value of the loss in Tsh ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________

C: VEGETABLE MARKETING		
C1	Do you sell your vegetable produce	0 = No 1 = Yes

C2	If No to qn C1: Give reasons ____ ____		
	If Yes to C1; Which market outlet do you mostly sell your vegetables during low season?		
C3	African Eggplant: _____________		1 = Farm gate;
C4	Amaranth: ____________		2 = Whole sellers;
C5	Tomatoes: ____________		3 = Retailer
	If Yes to C1; Which market outlet do you mostly sell your vegetables during low season?		
C6	African Eggplant: ______________		1 = Farm gate;
C7	Amaranth: _________________		2 = Whole sellers;
C8	Tomatoes: _________________		3 = Retailer
C12	Do you transport your vegetables to the market? _______		0 = No 1 = Yes
C13	How far is the nearest market where you sell your vegetables? ______________Km		
	Does the household own the transportation asset?		Who in the household have the access to the asset?
C14			1 = Husband; 2 = Wife; 3 = Both
C15	Bicycle: ______ 0 = No 1 = Yes	C19	Bicycle: ________
C16	Motorbike: _____ 0 = No 1 = Yes	C20	Motorbike: _____
C17	Ox cart: _________ 0 = No 1 = Yes	C21	Ox cart: _________
C18	Car: ________ 0 = No 1 = Yes	C22	Car: __________
	Truck: ______ 0 = No 1 = Yes	C23	Truck: ____________
	What type of transport mode do you mostly use during transportation of vegetable produce?		
C24	Head: ___________		0 = No 1 = Yes
C25	Bicycle: ___________		0 = No 1 = Yes
C26	Motorbike: ___________		0 = No 1 = Yes
C27	Ox cart: ___________		0 = No 1 = Yes
C28	Car: ________________		0 = No 1 = Yes
C29	Truck: ______________		0 = No 1 = Yes
	What is the cost of transportation of transportation?		
C30	Head; ____________________________Tsh		
C31	Bicycle: __________________________ Tsh		
C32	Motorbike: ________________________Tsh		

C33 C34 C35	Ox cart: __________________________Tsh Car: _____________________________Tsh Truck: ___________________________Tsh	
C36	Why do you use that particular mode? _____________	1 = No alternative; 2 = Cheap; 3 = To carry more; 4 = Faster **999=I don't know**
C37	What is the nature/type of the road? ________________	0 = Weather road; 1 = Murram; 2 = Tarmac; 3 = Other
C38	Do you pack your produce during transportation?	0 = No 1 = Yes
C39	If NO to question C29: Give reason ____	
C40	If YES in C29: What are the packaging materials? __________ Other; Specify _______________________________	0 = Plastic bag: 1 = Bamboo basket; 2 = Wooden create; 3 = Plastic create; 999 = I don't know/Missing
C41	Do you store your produce during the marketing process? _______	0 = No 1 = Yes
C42	If yes to question C32; What is the storage condition?___________	0= Normal temp; 1 = controlled temp
 C43 C44 C45	How do you store your produces? African Eggplant: ____________________________ Amaranth: __________________________________ Tomatoes: __________________________________	
 C46 C47 C48	How long do you store your vegetable before selling? African Eggplant: _____________ days Amaranth: ________________days Tomatoes: ________________days	
 C49 C50 C51	How long can the vegetables be stored with the acceptable quality? African Eggplant: _____________ days Amaranth: ________________days Tomatoes: ________________days	

	Do you sort/grade vegetables?	
C52	African Eggplant ______________	0 = No 1 = Yes
C53	Amaranth: _________________	0 = No 1 = Yes
C54	Tomatoes: _________________	0 = No 1 = Yes
C55	Does the price differ from different grades? _________	0 = No 1 = Yes
C56	Do you incur any cost from vegetable storage? ______	0 = No 1 = Yes
	If Yes to question C49; How much per day?	
C57	African Eggplant: ______________Tsh	
C58	Amaranth: ____________________Tsh	
C59	Tomatoes: _____________________Tsh	
C60	Do you sell your vegetable individual? ____________	0 = No 1 = Yes
C61	If Yes C54; Give reason __________	1 = You don't sell at the same time; 2 = You don't sell at the same market; 3 = You have conflict 4= They will degrade your produce 5 = Few customers 6 = Quantity is small 999 = I don't know/Missing
C62	Do you sell your vegetables in a group? _____________	0 = No 1 = Yes
C63	If Yes C56: Give reason ____ ____	1 = It lower the cost 2 = It increases bargaining power 3 = Share market information 999 = I don't know/ Missing
C64	Do you always find market for all your vegetables? _______________	0 = No 1 = Yes
	If NO to C58: What happens to unsold vegetables?	
C65	Lose to spoilage: _______________	0 = No 1 = Yes
C66	Eat (Family and friends): ________________	0 = No 1 = Yes
C67	Used as animal (livestock) feeds:_______________	0 = No 1 = Yes
C68	Do you experience problems in marketing your vegetables?	0 = No 1 = Yes
	If Yes to C63: What problems do you encounter?	
C69	Poor roads: _____________	0 = No 1 = Yes

C70	High transport costs: _________________	0 = No 1 = Yes
C71	Low prices: ________________	0 = No 1 = Yes
C72	Low demand: ___________________	0 = No 1 = Yes
C73	Poor storage facilities: ___________________	0 = No 1 = Yes
C74	Lack of markets: _______________________	0 = No 1 = Yes
C75	High spoilage rate of vegetables: __________________	0 = No 1 = Yes
C76	High processing costs: ________________________	0 = No 1 = Yes
C77	Lack of market information: ____________________	0 = No 1 = Yes
C78	High local taxes (road taxes and market dues): ________	0 = No 1 = Yes
C79	Unorganized farmers: _________________________	0 = No 1 = Yes
C78	Thieves: _________________________	0 = No 1 = Yes

D: POST-HARVEST HANDLING PRACTICE AND TECHNIQUE		
D1	Do you use any post-harvest handling practice and technique? _____________	0 = No 1 = Yes
D2	If No to D1; Give reason ____	
	If Yes to D1;What are post-harvest handling practice and technique do you use in African Eggplant?	
D3	Maturity indices: ___________________	0 = No 1 = Yes
D4	Shade: ____________________	0 = No 1 = Yes
D5	Sorting/grading: _________________	0 = No 1 = Yes
D6	Use of improved containers: ______________	0 = No 1 = Yes
D7	Washing/hygiene: ________________	0 = No 1 = Yes
D8	Solar drying: _____________	0 = No 1 = Yes
D9	Cooling: _________________	0 = No 1 = Yes
	Others: __________________	0 = No 1 = Yes
	If Yes to D1;What are post-harvest handling practice and technique do you use in Amaranth?	
D10	Maturity indices: ___________________	0 = No 1 = Yes
D11	Shade: ____________________	0 = No 1 = Yes
D12	Sorting/grading: _________________	0 = No 1 = Yes
D13	Use of improved containers: ______________	0 = No 1 = Yes
D14	Washing/hygiene: ________________	0 = No 1 = Yes
D15	Solar drying: _____________	0 = No 1 = Yes
D16	Cooling: _________________	0 = No 1 = Yes

	Others: __________________	0 = No 1 = Yes
	If Yes to D1;What are post-harvest handling practice and technique do you use in Tomatoes?	
D17	Maturity indices: ___________________	0 = No 1 = Yes
D18	Shade: ____________________	0 = No 1 = Yes
D19	Sorting/grading: _________________	0 = No 1 = Yes
D20	Use of improved containers: ______________	0 = No 1 = Yes
D21	Washing/hygiene: ________________	0 = No 1 = Yes
D22	Solar drying: _____________	0 = No 1 = Yes
D23	Cooling: _________________	0 = No 1 = Yes
	Others: __________________	0 = No 1 = Yes
	Does the choice of using maturity indices influenced by the	
D24	following?	0 = No 1 = Yes
D25	Quantity of vegetable harvested: ____________	0 = No 1 = Yes
D26	Farming experience: ____________	0 = No 1 = Yes
D27	Investment cost: _____________	0 = No 1 = Yes
	Price of vegetables: ___________	0 = No 1 = Yes
	Others: __________	
	Does the choice of using shade influenced by the following?	
D28	Quantity of vegetable harvested: ____________	0 = No 1 = Yes
D29	Farming experience: ____________	0 = No 1 = Yes
D30	Investment cost: _____________	0 = No 1 = Yes
D31	Price of vegetables: ___________	0 = No 1 = Yes
	Others: __________	0 = No 1 = Yes
	Does the choice of sorting/grading influenced by the following?	
D32	Quantity of vegetable harvested: ____________	0 = No 1 = Yes
D33	Farming experience: ____________	0 = No 1 = Yes
D34	Investment cost: _____________	0 = No 1 = Yes
D35	Price of vegetables: ___________	0 = No 1 = Yes
	Others: __________	0 = No 1 = Yes
	Does the choice of using improve container/creates influenced by	
D36	the following?	0 = No 1 = Yes
D37	Quantity of vegetable harvested: ____________	0 = No 1 = Yes
D38	Farming experience: ____________	0 = No 1 = Yes
D39	Investment cost: _____________	0 = No 1 = Yes
	Price of vegetables: ___________	0 = No 1 = Yes

	Others: __________	
	Does the choice of washing/hygiene influenced by the following?	
D40	Quantity of vegetable harvested: ____________	0 = No 1 = Yes
D41	Farming experience: ____________	0 = No 1 = Yes
D42	Investment cost: _____________	0 = No 1 = Yes
D43	Price of vegetables: ___________	0 = No 1 = Yes
	Others: __________	0 = No 1 = Yes
	Does the choice of drying influenced by the following?	
D44	Quantity of vegetable harvested: ____________	0 = No 1 = Yes
D45	Farming experience: ____________	0 = No 1 = Yes
D46	Investment cost: _____________	0 = No 1 = Yes
D47	Price of vegetables: ___________	0 = No 1 = Yes
	Others: __________	0 = No 1 = Yes
	Does the choice of cooling influenced by the following?	
D48	Quantity of vegetable harvested: ____________	0 = No 1 = Yes
D49	Farming experience: ____________	0 = No 1 = Yes
D50	Investment cost: _____________	0 = No 1 = Yes
D51	Price of vegetables: ___________	0 = No 1 = Yes
	Others: __________	0 = No 1 = Yes
D52	Is vegetable production/sale a viable business?	0 = No 1 = Yes
D53	What do you think is/are the greatest problem in vegetable production ____	
D54	What do you think could be improved in the vegetable production and marketing? ____	
D55	What do you think could be done to reduce vegetable post-harvest losses? ____	

QUESTIONNAIRE FOR ECONOMIC COST QUANTIFICATION OF SELECTED VEGETABLES POSTHARVEST LOSSES IN BABATI DISTRICT TANZANIA

(Retailers/wholesalers')

Questionnaire Number [ ]

Enumerator name: ________________	Date: _______________________________

A1	Name of the respondent:	____
A2	Tel. no:	____
A3	District: **BABATI**	
A4	Town/Village: _____________	Gallapo = 1; Matufa = 2; Bermi = 3; Seloto = 4
A5	Sex of the respondent? _____	Female = 0; Male = 1
A6 A7 A8 A9 A10	*Demographic data respondent:* Position of respondent: _________ Sex: ______ Age (years): ______ Educational Level (years): ________ Farming Experience in Veg. Production (years) __________	1= H/Head ; 2= Wife; 3= Child; 4=Relative 0 = Female 1 = Male
A11	Marital Status _______	1= Married 2 = Single 3 = Divorced 4 = Separated 5.Widowed
A12	Major Occupation ______	1= Farming 2=Salaried Employee 3= Hired worker
A13 A14 A15 A16	What is the household size and gender composition? Total: _____ Men (adult): ______ Women (Adult): ______ Children (under 18) ______	
A17 A18 A19	What is the household's age structure? 0 – under 18 years: _______ 18 - 60 years: _______ Above 60: ________	
A20 A21 A22 A23	What is the household's average income category per month? Total: ______ Husband: ______ Wife: _______ Other: _______	

	(if other please specify): ……………………..	

B: VEGETABLE PRODUCTION AND FARMING DECISION		
B1	What is your major objective in vegetable selling? (tick the appropriate one): _____	1= Making Profits 2 = Support the family; 3 = Reduce risk of hunger; 4 = As a way of life; 5 = Have no other option (could abandon farming) ; 6 = Others ***999 = I don't know/missing***
	If other, please specify: _________________________	
B2	Do you grow vegetables for selling?	0 = No 1 = Yes
B3	What is your total land endowment? _________acres.	***999 = I don't know/missing***
B4	What farm size allocated to vegetable cultivation? ______acres.	***999 = I don't know/missing***
B5	How is that land owned? _________	1= Owned ; 2= Rented ; 3=Borrowed; ***999 =I don't know/Missing***
 B6 B7 B8 B9 B10 B11 B12 B13	Who in the household decides on; Land use decision? ___________ Production decision? ___________________ Produces the vegetable? (actively works on farm) ___ Income from vegetable production? _____________ Utilisation of vegetable produce? ____________ How the vegetable produce is stored? __________ How the vegetable produce is marketed? _________ In charge of the timing of the marketing? _________	1 = Husband; 2 = Wife; 3= Both (Husband and Wife) 4 = Husband, Wife and Children 99***9 = I don't know/ Missing***

B14	Carrying out the actual selling of produce? _________			
 B15 B16 B17	How much did you buy per week? African Eggplant; ___________Kg Amaranth; ________________Kg Tomatoes; ______________Kg		 B16 B17 B18	How much did you sell per week? African Eggplant; ___________Kg Amaranth; ________________Kg Tomatoes; ________________Kg
B19 B20 B21 B22	How many (Kg) of vegetable produce used as a food? African Eggplant:_______________ Amaranths: _______________ Tomatoes: ________________		 B23 B24 B25	What % used as food? African Eggplant:__________________% Amaranths: ________________% Tomatoes: _________________%
  B26 B27 B28	How many Kg of vegetable produce used for other purposes? African Eggplant:____________________ Amaranths: _____________________ Tomatoes: ________________		 B29 B30 B31	What % used for other purposes? African Eggplant:__________________% Amaranths: ________________% Tomatoes: _________________%
  B31 B32 B33 B34 B35 B36 B37 B38 B39 B40 B41 B42 B43 B44 B45	What is/are the factors contributing to post-harvest losses in vegetables? ***0 = No 1 = Yes*** Education level: _________ Experience in Veg. farming: _____ Farm size: ___________________ Harvesting method: ___________ Time of harvesting: ___________ Loading/Off-loading: ___________ Distance to the market: __________ Nature of the road: _____________ Mode of transportation: _________ Contamination: _______________ Storage condition: _____________ Packaging materials: ___________ Financial Constraints: ___________ Labor Constraints: _____________ Gender of the responsible person: ____________	 B46 B47 B48 B49 B50 B51 B52 B53 B54 B55 B56 B57 B58 B59 B60	If **Yes/No;** Give reason ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________		
B61	How much is lost (African Eggplanta0 due to the following reason?		B70	Value of the loss in Tsh ____________________________

B62 B63 B64 B65 B66 B67 B68 B69	Harvesting method: _______________Kg Time of harvesting: _______________Kg Loading/Off-loading: ______________Kg Distance to the market: _____________Kg Nature of the road: ________________Kg Mode of transportation: ____________Kg Contamination: ___________________Kg Storage condition: _________________Kg Packaging materials: _______________Kg	B71 B72 B73 B74 B75 B76 B77 B78	______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________
 B79 B80 B81 B82 B83 B84 B85 B86 B87	How much is lost (Amaranth) due to the following reason? Harvesting method: ________________Kg Time of harvesting: ________________Kg Loading/Off-loading: _______________Kg Distance to the market: ______________Kg Nature of the road: _________________Kg Mode of transportation: _____________Kg Contamination: ____________________Kg Storage condition: _________________Kg Packaging materials: _______________Kg	 B88 B89 B90 B91 B92 B93 B94 B95 B96	Value of the loss in Tsh ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________
  B97 B98 B99 B100 B101 B102 B103 B104 B105	How much is lost (Tomatoes) due to the following reason? Harvesting method: _______________Kg Time of harvesting: ________________Kg Loading/Off-loading: _______________Kg Distance to the market: _____________Kg Nature of the road: _________________Kg Mode of transportation: _____________Kg Contamination: ____________________Kg Storage condition: _________________Kg Packaging materials: _______________Kg	 B106 B107 B108 B109 B110 B111 B112 B113 B114	Value of the loss in Tsh ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________

C: VEGETABLE MARKETING		
C1	Do you sell your vegetable produce	0 = No 1 = Yes
C2	If No to qn C1: Give reasons ____	
	If Yes to C1; Which market outlet do you mostly sell	

C3 C4 C5	your vegetables during low season? African Eggplant: _____________ Amaranth: ____________ Tomatoes: ____________	1 = Farm gate; 2 = Whole sellers; 3 = Retailer
C6 C7 C8	If Yes to C1; Which market outlet do you mostly sell your vegetables during low season? African Eggplant: ______________ Amaranth: _________________ Tomatoes: _________________	1 = Farm gate; 2 = Whole sellers; 3 = Retailer
C9 C10 C11	In average how much do you sell per week? African Eggplant: _________________Kg Amaranth: _______________________Kg Tomatoes: _______________________Kg	
C12	Do you transport your vegetables to the market? __________	0 = No 1 = Yes
C13	How far is the nearest market where you sell your vegetables? ______________Km	

C14 C15 C16 C17 C18	Does the household own the transportation asset? Bicycle: _____ 0 = No 1 = Yes Motorbike: ___ 0 = No 1 = Yes Ox cart: ______ 0 = No 1 = Yes Car: _____ 0 = No 1 = Yes Truck: ___ 0 = No 1 = Yes	C19 C20 C21 C22 C23	Who in the household have the access to the asset? 1 = Husband; 2 = Wife; 3 = Both Bicycle: _______ Motorbike: _____ Ox cart: _________ Car: __________ Truck: ____________

C24 C25 C26 C27 C28 C29	What type of transport mode do you mostly use during transportation of vegetable produce? Head: ___________ Bicycle: ___________ Motorbike: ___________ Ox cart: ___________ Car: ________________ Truck: ______________	0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes
C30	What is the cost of transportation of transportation? Head; _____________________________Tsh	

C31 C32 C33 C34 C35	Bicycle: __________________________ Tsh Motorbike: ________________________Tsh Ox cart:___________________________Tsh Car: ______________________________Tsh Truck: ____________________________Tsh	
C36	Why do you use that particular mode? ______________	1 = No alternative; 2 = Cheap; 3 = To carry more; 4 = Faster **999=I don't know**
C37	What is the nature/type of the road? _________________	0 = Weather road; 1 = Morram; 2 = Tarmac; 3 = Other
C38	Do you pack your produce during transportation?	0 = No 1 = Yes
C39	If NO to question C29: Give reason:	
C40	If YES in C29: What are the packaging materials? ___________	0 = Plastic bag: 1 = Bamboo basket; 2 = Wooden create; 3 = Plastic create; 999 = I don't know/Missing
C41	Do you store your vegetables during the marketing process? ________	0 = No 1 = Yes
C42	If yes to question C32; What is the storage condition?___________	0= Normal temp; 1 = controlled temp
 C43 C44 C45	How do you store your produces? African Eggplant: _____________________________ Amaranth: _____________________________________ Tomatoes: _______________________________________	
 C46 C47 C48	How long do you store your vegetable before selling? African Eggplant: ______________ days Amaranth: _________________days Tomatoes: _________________days	
 C49	How long can the vegetables be stored with the acceptable quality? African Eggplant: ______________ days	

C50 C51	Amaranth: _________________days Tomatoes: _________________days	
 C52 C53 C54	Do you sort/grade vegetables? African Eggplant ______________ Amaranth: _________________ Tomatoes: _________________	 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes
C55	Does the price differ from different grades? _________	0 = No 1 = Yes
C56	Do you incur any cost from vegetable storage? _______	0 = No 1 = Yes
 C57 C58 C59	If Yes to question C49; How much per day? African Eggplant: ______________Tsh Amaranth: ____________________Tsh Tomatoes: _____________________Tsh	
C60	Do you sell your vegetable individual? ____________	0 = No 1 = Yes
C61	If Yes C54; Give reason ___________	1 = You don't sell at the same time; 2 = You don't sell at the same market; 3 = You have conflict 4= They will degrade your produce 5 = Few customers 6 = Quantity is small 999 = I don't know/Missing
C62	Do you sell your vegetables in a group? _____________	0 = No 1 = Yes
C63	If Yes C56: Give reason ____	1 = It lower the cost 2 = It increases bargaining power 3 = Share market information 999 = I don't know/ Missing
C64	Do you always find market for all your vegetables? _____	0 = No 1 = Yes
 C65 C66 C67	If NO to C58: What happens to unsold vegetables? Lose to spoilage: _______________ Eat (Family and friends): ________________ Used as animal (livestock) feeds:_______________	 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes
C68	Do you experience problems in marketing your vegetables?	0 = No 1 = Yes
	If Yes to C63: What problems do you encounter?	

C69	Poor roads: ____________	0 = No 1 = Yes
C70	High transport costs: _________________	0 = No 1 = Yes
C71	Low prices: ________________	0 = No 1 = Yes
C72	Low demand: ___________________	0 = No 1 = Yes
C73	Poor storage facilities: ___________________	0 = No 1 = Yes
C74	Lack of markets: _______________________	0 = No 1 = Yes
C75	High spoilage rate of vegetables: __________________	0 = No 1 = Yes
C76	High processing costs: ________________________	0 = No 1 = Yes
C77	Lack of market information: ____________________	0 = No 1 = Yes
C78	High local taxes (road taxes and market dues): ________	0 = No 1 = Yes
C79	Unorganized farmers: _________________________	0 = No 1 = Yes
C78	Thieves: _________________________	0 = No 1 = Yes

D: POST-HARVEST HANDLING PRACTICE AND TECHNIQUE		
D1	Do you use any post-harvest handling practice and technique? _____________	0 = No 1 = Yes
D2	If No to D1; Give reason ___________________________________	
	If Yes to D1; What are post-harvest handling practice and technique do you use in African Eggplant?	
D3	Maturity indices: ___________________	0 = No 1 = Yes
D4	Shade: ____________________	0 = No 1 = Yes
D5	Sorting/grading: _________________	0 = No 1 = Yes
D6	Use of improved containers: ______________	0 = No 1 = Yes
D7	Washing/hygiene: ________________	0 = No 1 = Yes
D8	Solar drying: _____________	0 = No 1 = Yes
D9	Cooling: _________________	0 = No 1 = Yes
	Others: __________________	0 = No 1 = Yes
	If Yes to D1;What are post-harvest handling practice and technique do you use in Amaranth?	
D10	Maturity indices: ___________________	0 = No 1 = Yes
D11	Shade: ____________________	0 = No 1 = Yes
D12	Sorting/grading: _________________	0 = No 1 = Yes
D13	Use of improved containers: ______________	0 = No 1 = Yes
D14	Washing/hygiene: ________________	0 = No 1 = Yes
D15	Solar drying: _____________	0 = No 1 = Yes

D16	Cooling: _________________ Others: __________________	0 = No 1 = Yes 0 = No 1 = Yes
	If Yes to D1; What are post-harvest handling practice and technique do you use in Tomatoes?	
D17 D18 D19 D20 D21 D22 D23	Maturity indices: ___________________ Shade: ____________________ Sorting/grading: _________________ Use of improved containers: ______________ Washing/hygiene: ________________ Solar drying: _____________ Cooling: _________________ Others: __________________	0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes
  D24 D25 D26 D27	Does the choice of using maturity indices influenced by the following? Quantity of vegetable harvested: ____________ Farming experience: ____________ Investment cost: _____________ Price of vegetables: ___________ Others: __________	 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes
 D28 D29 D30 D31	Does the choice of using shade influenced by the following? Quantity of vegetable harvested: ____________ Farming experience: ____________ Investment cost: _____________ Price of vegetables: ___________ Others: __________	 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes
 D32 D33 D34 D35	Does the choice of sorting/grading influenced by the following? Quantity of vegetable harvested: ____________ Farming experience: ____________ Investment cost: _____________ Price of vegetables: ___________ Others: __________	 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes
  D36 D37 D38	Does the choice of using improve container/creates influenced by the following? Quantity of vegetable harvested: ____________ Farming experience: ____________ Investment cost: _____________	 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes 0 = No 1 = Yes

D39	Price of vegetables: ___________ Others: __________	0 = No 1 = Yes
	Does the choice of washing/hygiene influenced by the following?	
D40	Quantity of vegetable harvested: ____________	0 = No 1 = Yes
D41	Farming experience: ____________	0 = No 1 = Yes
D42	Investment cost: _____________	0 = No 1 = Yes
D43	Price of vegetables: ___________	0 = No 1 = Yes
	Others: __________	0 = No 1 = Yes
	Does the choice of drying influenced by the following?	
D44	Quantity of vegetable harvested: ____________	0 = No 1 = Yes
D45	Farming experience: ____________	0 = No 1 = Yes
D46	Investment cost: _____________	0 = No 1 = Yes
D47	Price of vegetables: ___________	0 = No 1 = Yes
	Others: __________	0 = No 1 = Yes
	Does the choice of cooling influenced by the following?	
D48	Quantity of vegetable harvested: ____________	0 = No 1 = Yes
D49	Farming experience: ____________	0 = No 1 = Yes
D50	Investment cost: _____________	0 = No 1 = Yes
D51	Price of vegetables: ___________	0 = No 1 = Yes
	Others: __________	0 = No 1 = Yes
D52	Is vegetable production/sale a viable business?	0 = No 1 = Yes
D53	What do you think is/are the greatest problem in vegetable production ____	
D54	What do you think could be improved in the vegetable production and marketing? ____	
D55	What do you think could be done to reduce vegetable post-harvest losses? ____	

THANK YOU