ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

Supply Chain Management (SCM) Approach to Reduce Post-harvest Losses with Special Emphasis on Cabbage Supply from Akaki to Addis Ababa

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirement for the Degree of Master of Science in Civil Engineering (Road and Transport Engineering)

By

Dimtsu Gebremariam Hagos

E-mail: dmtsu99@yahoo.com

Advisor

Prof. Girma Gebresenbet

Addis Ababa, Ethiopia

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Dimtsu Gebremariam Hagos

E-mail: dmtsu99@yahoo.com

Advisor

Prof. Girma Gebresenbet

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Declaration

I hereby declare that this thesis is my own work towards the degree of Master of Science and that, to the best of my knowledge; it contains neither materials previously published by another person nor materials, which have been submitted for the award of any other degree of the University.

Approved By Board of Examiners

Professor Girma Gebresenbet Advisor	_ _ _ _ _ _ _ _	_ _ _ _ _ _
_____ Internal Examiner	_ _ _ _ _ _ _ _	_ _ _ _ _ _
_____ External Examiner	_ _ _ _ _ _ _ _	_ _ _ _ _ _
_____ Chairperson	_ _ _ _ _ _ _ _ _ Signature	_ _ _ _ _ _ Date

Dedication

This thesis is dedicated to my wife, Meseret Wolde, and my lovely first born daughter, Fikir Meseret Dimtsu.

Abstract

Fruits and vegetables are highly perishable agricultural produces and their post-harvest loss is great in amount. Producers suffer a huge economic loss due to lack of proper understanding about causes and nature of losses, preservation methods, and transportation and marketing. Cabbage, which is highly nutritious vegetable, is an economically important vegetable in Ethiopia and one of the most widely cultivated vegetables in South of Addis Ababa particularly in Akaki area following the Akaki Rivers.

This thesis work was conducted to assess the existing conditions of cabbage supply chain, identify/asses the causes and amount of post harvest loss of the produce using the supply chain management approach, and thereafter come up with possible/appropriate loss controlling mechanisms. Moreover, it was conducted by aiming to be an initial/base point for conducting future research works on each of the different causes of post harvest losses identified and their controlling mechanisms set by this study.

Seventy-two respondents from farm, local market, wholesale and retail market levels were selected using both random and non-random sampling techniques, and then primary data was collected through interviews, questionnaires and personal observations. Furthermore, to consider the consumer level, 30 cabbage samples were selected from wholesale and retail levels using non-random (quota type) technique. The data collected was both qualitative and quantitative data and analyzed using spreadsheet.

Higher storage/transportation temperature, mechanical damage during transportation, disease infection, poor quality of irrigation water, poor storage mechanisms were found as the reasons of post harvest loss of cabbage supplied from Akaki. The total post harvest loss of the produce within the supply chain was found to be 58.9 %, which is high.

Keeping the transportation/storage temperatures lower, using appropriate packaging materials, maintaining the quality of irrigation water, proper handling and storage are some of the recommended solutions to reduce the post harvest loss of the produce.

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1. Introduction

1.1. Background and problem statement

Vegetables are among the most nutritious agricultural products and are widely and preferably consumed fresh. They are common sources of food and income for both farmers and marketers (who are involved in transportation, distribution and trading of vegetable products), though the income/profit they get is low even compared to the amount they produce with high labor inputs [1].

As other leafy vegetables, cabbage is highly nutritious vegetable and has so many health benefits. It is rich in phyto-nutrient anti-oxidants that are powerful oxidants and known to help protect against breast, colon, and prostate cancers and help reduce LDL or "bad cholesterol" levels in the blood. Moreover, fresh cabbage is an excellent source of natural antioxidant, vitamin C that helps the body develop resistance against infectious agents and scavenge harmful, pro-inflammatory free radicals [1].

It is also rich in essential vitamins such as vitamin B-5, vitamin B-6 and thiamin (vitamin B-1), vitamin K and minerals like potassium, manganese, iron, magnesium. In a cup of cooked cabbage, it has only 33 calories, is low in fat and high in fiber and is ideal for weight loss [1].

However, cabbage and other fresh vegetables are highly perishable and subject to rapid quality deterioration after harvest due to incorrect stage of produce maturity, water loss, unfavorable climatic condition, physical damage, contamination by pathogens and insect pests, improper handling and poor storage conditions. Other factors also contribute to postharvest loss, such as lack of capable human resources, lack of knowledge about technical and scientific technologies, inefficient marketing systems, poor/lack of transportation infrastructures etc.

Post harvest loss of vegetables is the loss of edible part of a produce after being harvested because of the above reasons. The post-harvest sector includes all points in the value

chain from production in the field to the food being placed for consumption. Postharvest activities include harvesting, handling, storage, processing, packaging, transportation and marketing.

Different studies showed that the post harvest losses of vegetables within supply chain ranges from 20 to 30 %, and this figure increases in developing countries due to lack of awareness, infrastructures, storage facilities and poor handling, etc. For instance, postharvest losses are 25-40% for vegetable crops in Cambodia, and 25-30% in Vietnam [2, 3]. In addition, the post harvest losses of vegetables in Egypt are around 30 % [4].

The post harvest losses of cabbage in the domestic supply chains of Lao PDR were 30% at the farms level, 3% at the collectors' level, 9.6% at the wholesalers' level and 4% at the retailers' level [5]. This is a huge loss of valuable food even when the minimum food requirement of the population is not met.

Postharvest losses of vegetables contribute to food insecurity, poverty, and economic hopelessness in developing countries like Ethiopia. The two principal gaps in controlling these losses are the inadequacies in fresh produce handling and processing, and lack of awareness and adoption of available technologies. Bridging these gaps would minimize postharvest losses of vegetables, thus play role in poverty alleviating. Reducing postharvest losses through appropriate postharvest technologies for fresh and processed produce would not only increase food availability to the growing world population but also decrease the area needed for production and conserve natural resources [4].

There are various techniques for handling fresh vegetables and thus minimize postharvest losses in the supply chain. Knowing these techniques widens alternatives for adaptation and opens more opportunities for innovation. While there are many postharvest technologies that extend the market availability of vegetables, the appropriateness of these technologies has to be determined through site specific and commodity-specific studies. A technology proven effective and commercially used elsewhere is not necessarily the best for use under conditions of another country. Technologies developed

in a developing country may better suit the need of another developing country, as they typically are much simpler and less costly than technologies created in developed countries [4].

Now a day, reducing postharvest losses has become only part of efforts to improve food availability; while, assuring quality and safety of vegetables are increasingly important as well. Reducing post harvest losses of vegetables play a great role in poverty alleviating of one's country. Producers and distributers can increase their competitiveness and maximize their market shares by providing higher quality, safe products and promoting lower prices through technological innovation.

Post harvest losses of vegetables with in the supply chains reduce the production and marketing efficiencies of growers and traders, and affect poverty alleviating strategy of countries. Farmers can grow more at farm level but it is valueless if there are huge postharvest losses and quality deteriorations of the produce at the same time. If the post-harvest loss is reduced largely, it may not be necessary to considerably increase the production of vegetables with the growing demand. The cost of preventing losses after harvest in general is less than preventing a similar additional amount of fruits and vegetables crop of the same quality [6].

Problems described before related to the postharvest losses of vegetables are clearly visible in Ethiopia, which is one of the developing countries in Africa. This was the reason why this thesis was proposed to be conducted; to identify the real problems and provide possible solutions in the supply chain of leafy vegetable, cabbage, from Akaki to the city of Addis Ababa. Interviews, questionnaires and personal observations were used to know the current condition of supply chain in the study areas and identify the different sources of post harvest losses of the produce, hence, discussions, conclusions and recommendations are made accordingly.

1.2. Literature review

Vegetables, as they are composed of living cells, are highly perishable and prone to post harvest losses. Hence, to reduce excessive losses, these cells must be kept alive and healthy throughout the process of the supply chain.

Postharvest losses of leafy vegetables like cabbage; vary with type of varieties grown, location, growing season, and other factors such as standards of quality and consumer preferences and purchasing power, which differ greatly among countries and across cultures. Postharvest loss estimates in developing countries are alarming (20-50% of production) but efforts are lacking to establish the seriousness of the problem and the interventions needed [7].

Poor seed and production technologies can reduce productivity by 10-40% depending on commodity, and inadequate postharvest systems lead to losses of 20-35% depending on commodity [2]. The post harvest losses of perishable commodities like vegetables might be 80-100% in some instances. Postharvest losses determined at specific stages and outright volume loss of specific vegetables including the leafy types (Chinese cabbage) was estimated at an average of 17%. The loss situation may be more serious if qualitative losses (e.g. loss in price due to reduced quality, loss in nutritional quality, edibility or caloric value) were considered as factors [7].

Causes of postharvest losses of cabbage

Cabbage, as other leafy vegetables, undergoes a number of transfers during harvest, handling, packing and transportation stages. Each of these stages has the potential to reduce quality and therefore, subsequent postharvest life, causing injuries such as bruises, cuts, penetrations and abrasions or exposing the product with microorganisms that cause decays.

The main reasons for the post harvest losses of cabbage at the farmers' level were insect pest damages, rotting and over maturity. At the collectors level losses were because of

carless handling during pre-packing and packing operations, while at the wholesalers level causes of losses were bacterial soft rot [5].

Several factors contribute for the post-harvest losses of the leafy vegetable cabbage. The causes of losses are many and varied and can be broadly classified in to pre-harvest factors such as climatic conditions, cultural practices, quality of irrigation water, etc. and post harvest factors [6, 8].

a) Pre-harvest factors

Obtaining the optimum postharvest quality of vegetables actually begins very early in the farm planning process. The effects of pre-harvest factors on postharvest quality are often ignored and underestimated, and many of the decisions that we make during crop production can greatly influence the postharvest quality of crops. It is important to consider the factors that allow us to maximize the quality of the vegetables going into storage [8].

The postharvest quality of fruits and vegetables are largely determined by pre-harvest factors such as production location, soil type, irrigation, shading and nutrition. The study divided the pre-harvest factors into primary and secondary. The primary factors include climate, nutrition and plant growth regulators, and the secondary factors include soil quality and management, irrigation and crop load manipulation [8].

The influences of pre-harvest factors on postharvest quality of fruits and vegetables are described below [6, 8].

Climatic conditions: climatic factors, including temperature, light intensity and amount of rainfall, have a great impact on the postharvest quality of vegetables. As a result, the location and season at which these crops are grown can determine their mineral contents. Temperature influences uptake and metabolism of mineral nutrients by plants because transpiration increases with higher temperature. Rainfall affects the water supply to the

plant, which may influence composition of the harvested plant part and its susceptibility to mechanical damage during harvesting and handling operations [6, 8, 9, 10].

Farm practices: Soil fertility, irrigation, and fertilization influence the water and nutrient supply to the plant, which can affect the nutritional quality of the harvested vegetable produce [6, 8, 11]. These factors including pest control play important role in determining quality attributes such as size, color, firmness, flavor and nutritional values for the produce [9]. Adequate soil moisture during the pre-harvest period is essential for the maintenance of postharvest quality. Water stress during the growing season can affect the size of the harvested plant organ, and lead to soft or dehydrated produce that is more prone to damage and decay during storage. On the other hand, vegetables experiencing an excess of water during the growing season can show a dilution of soluble solids and acids, affecting flavor and nutritional quality. On the other hand, excess water supply results in cracking of vegetables such as headed cabbage [6, 11].

Excess moisture on the harvested vegetable can also increase the incidence of postharvest diseases. To minimize the amount of water on the harvested vegetable brought into storage, it may be beneficial to choose surface or subsurface irrigation rather than overhead irrigation. Vegetables harvested in the early morning, during rainy periods, and from poorly ventilated areas can also experience increased postharvest decay.

Maturity at harvest has a major impact on quality and shelf life of vegetables. Harvesting method can determine the extent of variability in maturity and physical injuries and consequently quality of the produce. Generally, produces harvested at the advanced stage of maturity have increased size and eating qualities [6, 8].

Apart from the poor water management and frequent over flooding during the heavy rainy season in the vegetable farms around Akaki River, there is great concern using fresh vegetables from this area as they are irrigated with municipal wastewater [12, 13]. The benefits of application of wastewater are constrained by the presence of pathogens, heavy metals and other pollutants that can be a health hazard to the consumers of

agricultural produce. The bacteriological and helminthes pollution of the Little Akaki River is very high and its pollution level is in an alarming stage. As a result, the river water is not fit for any use [14]. The hygienic safety of cabbage is threatened by various factors including poor quality irrigation water; as such, water could result in internal and external contaminations of vegetables.

b) Postharvest factors

Temperature and relative humidity: Temperature and relative humidity are also greatly responsible for reduction of the postharvest quality of vegetables. Produce should always be cooled as soon as possible after harvest to protect quality and extend shelf life. Once harvested, produce gains heat through respiration and conduction from the surrounding environment. Produces exposed to the sun after harvest, gains an enormous amount of heat and will have reduced shelf life [6].

Atmospheric temperature has been found to influence the shape, size, color and other quality parameters. Shelf life study conducted for cabbage stored at room temperature showed that color, flavor and texture changed to blackish, spoiled and very soft respectively after 9 days of storage [15]. Weight loss, respiration rate and ethylene production were also reduced at low temperatures and head firmness was maintained. Low temperature or cold storage is the single most effective method of prolonging the postharvest life of fresh produce [11, 15, 16]. The temperature at which you handle produce will directly affect how long you have to get the produce to market.

The relative humidity of the storage environment is also another aspect to consider during handling of vegetables. Loss of water from produce is often associated with a loss of quality, as visual changes such as wilting and textural changes can take place. Leafy crops such as cabbage tend to lose water the most quickly [15]. For fresh market produce, any method of increasing the relative humidity of the storage environment or decreasing the vapor pressure deficit between the commodity and its environment will slow the rate

of water loss. Generally, the best method of increasing relative humidity of the storage environment is to reduce the storage temperature.

The shelf life of cabbage stored at 0°C and relative humidity of greater than 98% is 3-6 weeks [17, 18]. At 4°C, cabbage can be stored successfully for 18 days, but it deteriorates rapidly and lasts only 4 days at ambient temperature of 28°C [15].

Storage and handling: Its perishable characteristics, lack of storage facilities, mechanical injuries due to improper handling, packaging, transportation and microbial infection are the major causes of post-harvest losses in fresh vegetables [3, 5, 11, 15].

Mechanical damage of cabbage is higher when it is transported in bulk due to increased self-weight, vibration and damage during loading and unloading. Spoilage rate of the produce in jute bag was the highest with 3.7% compared to carton and wood box packing materials. It is thought that cabbage in jute bag had mechanical damage due to high loading and vibration [19].

Vegetables are characterized by high metabolic activities and known to have short storage life. Due to the above mentioned factors, significant loss occurs on the supply chain between harvesting to consumption. Factors like insects, diseases due to non-infectious pathogens and pathological rots are also responsible for the post-harvest loss of cabbage. Pathological rots together with mechanical injury cause maximum damage to the perishables.

The storage of different foodstuffs, including different types of fruits and vegetables, in one room is often unavoidable in retail markets. It is a general practice for some distributors and retailers, since it is convenient. Unfortunately, when different types of fruit and vegetables are stored together at the same temperature, one foodstuff is often contaminated by odors given off by another. A second important problem is that the optimum storage temperatures and relative humidities for different produce vary widely. Ethylene gas is a hormone that stimulates fruit ripening and senescence. It also has a

harmful effect on vegetables. It is very important to avoid the storage of ethylene-producing products and ethylene-sensitive products together [11, 19].

Other aspects include limited value-addition; lack of market-oriented infrastructure such as cold chains, transportation and intermediary marketing centers. Weak engagement with the private sector in many cases leads to post-harvest interventions that are not commercially viable and generally unsustainable.

Inadequate postharvest systems for vegetables significantly contribute to the poor perception/image of domestically produced vegetables in Cambodia. Some of the major production districts are within 40 km of the markets, and as a result over 50% of vegetables reach the market on the back of motorbikes, motorbike trailers and bicycles. A high proportion of these are leafy vegetables, unsuited to such transportation, with deterioration during transport. Once at the market, there is little opportunity to maintain produce quality as the cool chain is nonexistent [2].

Methods to control postharvest losses

Amount of post-harvest loss in vegetables can be minimized by proper on farm site operations, harvesting, transportation, storage and pre and post- harvest treatments. Some of these are discussed below:

a) farm operations

Cultural operations, which ensure the normal development of leafy vegetables and avoid infection of decay organisms, will help to prolong their storage life. Heavy application of nitrogenous fertilizers causes faster tissue deterioration in vegetables, while essential supply of potassic fertilizers improves in keeping quality of leafy vegetables [11, 16].

b) Harvesting and field handling

The principal harvest maturity index for cabbage is based on size where heading-type cabbage may be harvested as small as 10 cm diameter and range until 15 to 25 cm [16].

Harvest maturity for headed type is also based on head compactness and firmness to touch. A firm or compact head is mature, can be only slightly compressed with moderate hand pressure while very loose head is immature, and should not be harvested [16]. Harvest maturity may also be based on arrangement of the wrapper leaves; when they are spread and the head is exposed it is usually mature. A mature cabbage has a well-developed head and good weight in comparison to its size. Unlike to Pak choi type, usually ready for harvest within 7 weeks, headed cabbage takes three month from seed to reach maturity, although this may vary according to cultivar and environmental conditions. [20].

Cabbage should be harvested promptly when the heads are firm and mature. Delaying harvest even a few days beyond maturity can result in split heads and increased disease pressure, particularly during wet weather [20].

Harvesting should be done at cooler time of the day and the produce should be shifted to the packing shade or temporary storage area as early as possible in order to maintain the quality. Harvesting during hot period raises the field heat of the produce and consequently wilting and drying may occur. Moreover, harvesting of vegetables during or immediately after the rains should not be carried out as it creates conditions most favorable for the multiplication of microorganisms [16].

c) Packaging

Packaging provides protection of the produce from mechanical damage, undesirable physiological changes and pathological deterioration during storage, transportation and marketing. Through proper packaging, freshness and flavor of vegetables can be maintained for a longer period [11,16].

A wide variety of containers such as wooden boxes, bamboo baskets, jute bags, earthen pots and corrugated fiberboard boxes are the important packaging materials used in most of the developing countries. Uniformity of head size and the proper count per container are important. There are three established size categories, small (0.8 kg or less), medium

(0.9-1.4 kg) and large (1.5 kg or larger). Normally 18 to 22 heads are packed in a 23 kg container. Cartons and crates are easier to stack and load and provide considerably more protection to the cabbage than mesh bags [20].

d) Pre-cooling

Prompt cooling conserves weight and reduces spread of pathogens, which gives an added advantage during the extended period of storage. It is desirable to remove field heat of the harvested vegetables, particularly when harvested during hot weather [6, 11, 15, 16,].

e) Transportation

Transportation and distribution of vegetables are the most important areas of post-harvest loss. For transporting vegetables from point of production to their point of consumption, different types of modes of transport are used, such as; trucks, pick-ups, motor bikes, horse carts etc. Quick transport of vegetable in order to maintain the quality with minimum damage during transportation is very important for successful marketing of the produce. The losses in transportation occur due to physical and mechanical injury and uncontrolled conditions, mainly temperature and humidity. The produce should be properly packed and stacked in well-ventilated carriages. Cooling and relative humidity control in carriages is of vital significance [3, 8, 11].

Efficient transportation system can go a long way, not only in reducing the post-harvest loss of horticultural produce but also in stabilizing the price fluctuations of the same commodity available in different markets. The surface of roads and their maintenance need improvement in order to have smooth transportation without severe jerks and vibration. The road transport can even become faster if all national highways are made one way and unnecessary delay caused by closure of the level crossing is prevented [16].

f) Marketing

To avoid the losses of vegetables, and get a good return from the produce, efficient marketing system is very essential. It is very important that the produce reach the market as soon as it is possible and at a time when the market needs it the most. Marketing of perishable horticultural products presents more problems compared to other durable agricultural products. Marketing is not efficiently managed in most of the developing countries. The interests of producers as well as consumers are poorly served, the grower gets less return and the consumer pays more than what is necessary [3, 11,16].

Sometimes, the market is in excess with a particular vegetable and a lot of wastage or loss is experienced. In addition, prices are considerably reduced and farmers get dejected. Therefore, this should be avoided and the market should be so facilitated as to reduce the loss to the minimum [16].

g) Low temperature storage

Storage is one of the most important aspects of post- harvest handling of vegetables. The main objective of storage is to extend the storage life of the produce and increase its period of availability. The post harvest loss of many vegetables can be prevented largely by controlling the storage conditions such as temperature, relative humidity and atmospheric concentration of certain gases [5, 6, 7, 11, 15, 16, 20, 21].

Success of postharvest technologies

Successful postharvest handling of vegetables requires carful coordination and integration of the various steps from harvest operations to consumer level in order to maintain the initial product quality. Two of the most critical means for maintaining vegetable quality during postharvest handling are minimizing mechanical injury and managing temperature. Proper handling and temperature management will significantly reduce losses due to decay and accelerated senescence [22].

When analyzing the adoption of specific postharvest technologies, they found that the simpler the postharvest technology, the better its chance for being still in use over the long term. If farmers can make more money by adopting a simple practice, then the use of a technology or technology package will be sustainable. Small scale postharvest practices such as the use of maturity indices to identify proper harvest timing, improved containers to protect from damage during handling and transport, the use of shade, sorting/grading to enhance market value, and use of on-farm storage practices are generally successful [16, 22].

Large scale efforts to provide packinghouses or complex postharvest infrastructure are generally less successful, due to problems with selection of sites (poor location for growers), high cost for energy required for operations, and the lack of trained local personnel needed for successful management [22].

Improvements to production technologies and supply chain management will not only reduce product losses but also improve the quality, safety and nutritive value of vegetables and fruits.

The reduction of post-harvest loss of vegetables is a complementary means for increasing production. It may not be necessary to considerably step up the production of vegetables with the growing demand if the post-harvest loss is reduced to a great extent. The cost of preventing losses after harvest in general is less than preventing a similar additional amount of fruit and vegetable crop of the same quality [17].

Generally, it was observed that the different sources of post harvest losses of leafy vegetables are not different in most of the studies (even though some factors like effect of the quality of irrigation water was not considered by most studies), but the practical solutions to reduce these losses in one country may not be effective/work in another country. Moreover, no any research work previously conducted in Ethiopia, particularly in Addis Ababa, regarding postharvest loss of cabbage with in supply chain was found. These were the main reasons why this thesis work was proposed to be conducted.

2. Objective

The main objective of this thesis work was to assess the post harvest losses of the cabbage supply from farms, Akaki, to the users' level in Addis Ababa and, find appropriate methodologies to minimize losses using the supply chain management approach. It was intended to create foundation for future researches on the identified causes of post harvest losses and the recommended loss controlling mechanisms set by this study.

The specific objectives were to**:**

- asses the existing conditions of supply chain of cabbage within the study area;
- identify the different sources of post harvest losses of cabbage within the supply chain;
- asses the amount of post harvest losses of cabbage within the supply chain; and to
- find better practical/possible solutions to reduce the post harvest losses.

3. Methodology

3.1. Study site

The study was conducted in Akaki and Addis Ababa, which are the production and distribution area of cabbage respectively.

Addis Ababa, which is the capital city of Ethiopia, is the largest city in the country with a population of about 3.4 million according to the 2007 population census. It is located at 9°1'48"N 38°44'24"E. From its lowest point, around 2,100 meters above sea level in the southern periphery around Akaki Kality sub-city, the city rises to over 3,000 meters in the Entoto Mountains to the north [23].

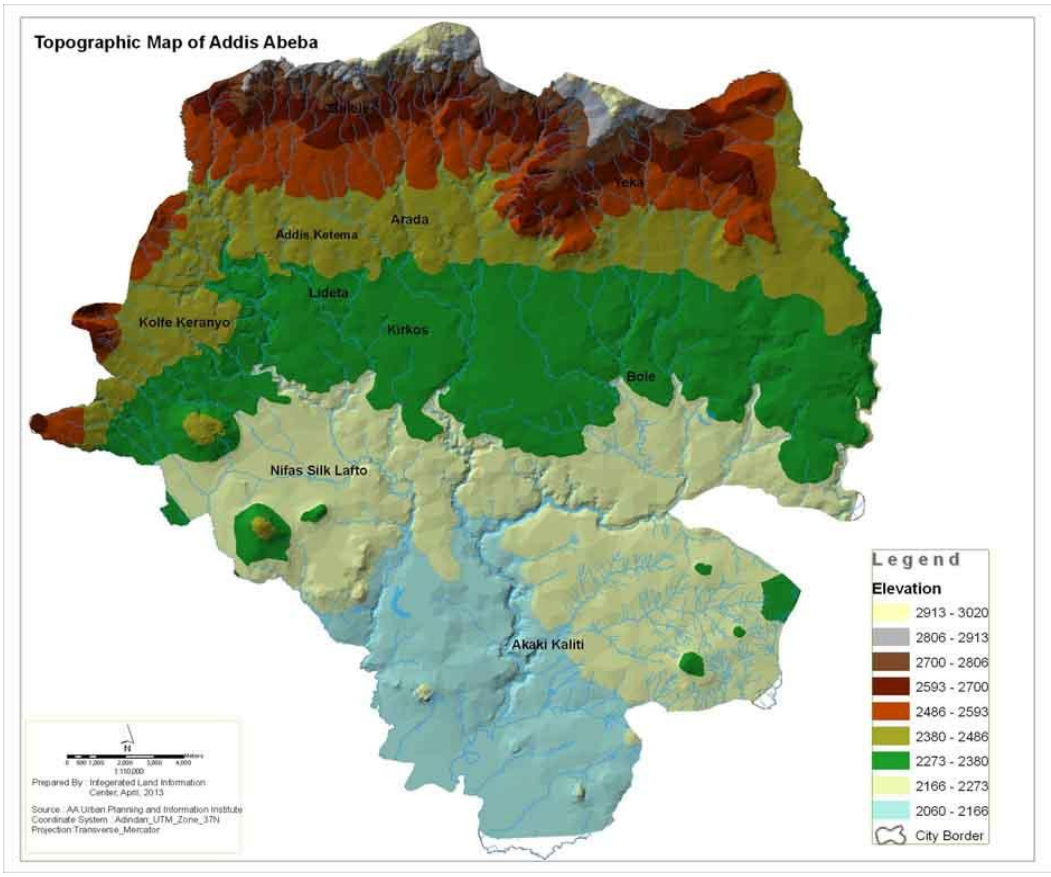


Figure 1: Topography map of Addis Ababa

As shown in figure 2, the hottest and coolest months of the city are May and January with average temperatures of 18°C and 15°C respectively. Mean monthly temperatures of the city have a variation of 3 °C, which is an extremely low range [24].

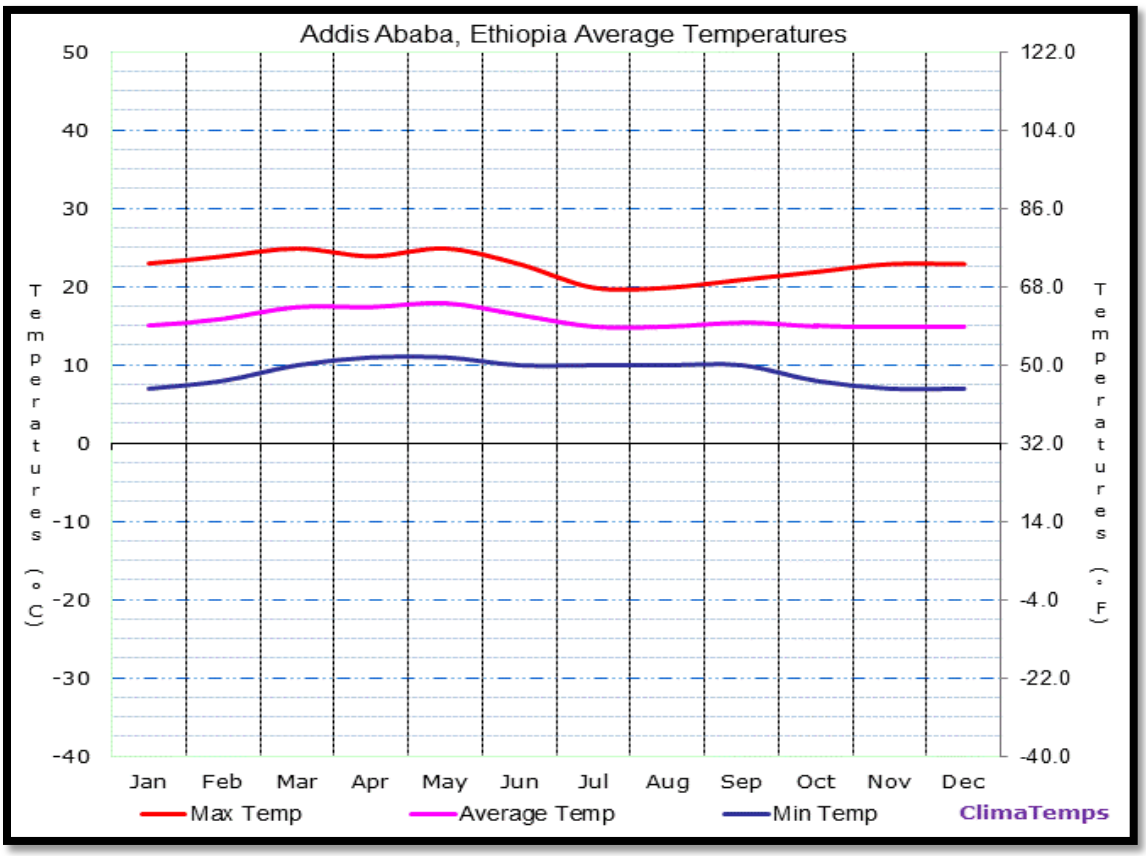


Figure 2: Average temperatures of Addis Ababa (2009-2014)

The 'Great' and 'Little' Akaki Rivers flow through the city both starting from the highest points (Northern mountainous areas), viz. Northeastern (Great Akaki) and Northwestern (Little Akaki) towards South of Addis Ababa through the Akaki Sub city, and converging at the Aba-Samuel Dam (Figure 27).

The traditional irrigation schemes grow vegetables along the Akaki River and supply about 30 % of the vegetable demand for Addis Ababa city [13]. In the city, cabbage is grown over 33 ha plot from where 1.6 million birr/year total net income is generated [25].

In addition to the supply of vegetables from Akaki, suppliers supply cabbage and other vegetables from different areas outside the city such as Dukem, Meki, Bishoftu etc.

Akaki Rivers has numerous seasonal and perennial small streams that flow into little and great Akaki Rivers. The streams were clean to a greater degree at the early days of establishment of Addis Ababa but the situation changed due to the high expanding industries and extensive population growth. These rivers are becoming receivers of all kinds of wastes; industrial wastewater is the primary causes of water pollution, followed by domestic wastewater and human excreta [12, 14].

Discharge of untreated effluent from industries, solid wastes and wastewater from households and institutions, are the major sources of pollution of the rivers flowing through the city. It was found that the concentration of heavy metals Manganese (1.6 mg/l), Cobalt and Cadmium around 0.1mg/l, which is higher than the maximum permissible concentration of these metals in irrigation water, set by World Health Organization (WHO), which are 0.2, 0.05 and 0.01 mg/l respectively [14].

The water management in the schemes was very poor and some of the traditional irrigation schemes are located in the river course and face frequent over flooding during heavy rainy season. Apart from that, there is great concern using fresh vegetables from these schemes as they are irrigated with municipal wastewater [13]. However, if the water pollution is alleviated and controlled, the rivers have good potential to be used for irrigation purpose so as play role in poverty reduction of the city.

The vegetable production around the rivers is carried mostly starting from October, as the rainy season (June, July and August) passes, except in some elevated areas that start from September. This is because the summer season is not suitable for vegetable growing and overflow of the rivers to the farm areas especially around the downstream as shown in Figure 3.

Figure 3: Great Akaki River on summer season and its impact on farmlands

3.2. Sampling

The total population of cabbage growers and retailers in the city is large and unknown. Hence, for populations that are large, and particularly for population where the total population is unknown, the sample size required is calculated as [26, 27, 28]:

$$n = \frac{Z^2}{e^2} p(1-p)$$

Where: n = sample size

Z = Confidence interval

p = degree of variability

e = precision rate

In this study a confidence level of 95% (Z = 1.96) was used as this is the level used most commonly in engineering researches, and since the variability is unknown, a degree of variability of 0.5 was used; and a precision rate of 5% was selected.

Therefore:

$$n = \frac{1.96^2}{0.05^2} * 0.5(1-0.5) = 384.16$$

At first, the sample size for each of the farm and retail levels was set to be 385. However, during conducting the survey, it was observed that harvesting and activities after harvest were carried mostly by the wholesalers, and as the sample size was found too large to conduct due to time and resource limitations, the sample sizes at the farm and retail levels were reduced to 10 and 42 respectively.

For conducting the survey, both Random and Non-random sampling techniques were used. Ten respondents at the farm level and five respondents at the local market level were selected using non-random (convenience type) way. Moreover, three wholesaling areas (Saries, Kerra and Atikilit Terra) were selected purposively (non-random) as these areas are the main vegetable wholesaling areas in the city and were areas of interest for this study. Fifteen cabbage wholesalers were found in these three areas and every wholesaler was included in the survey.

In the retailer level, six clusters (where the ten sub-cities considered as clusters of retailers) out of a total of ten clusters were selected using Simple Random Sampling (SRS) technique, then after, seven retailers were selected from each cluster in a non-random sampling (combination of quota and convenience type) way. To consider consumers level, a sample of 30 cabbage heads (15 from retailers and 15 from wholesalers) were selected in a non-random (quota type) way.

3.3. Data collection

Primary data was collected through interviews, questionnaires, personal observations and some measurements. The data collected was both quantitative and qualitative data, and analyzed using spreadsheet.

The different methodologies used for conducting this study were listed as follows.

1. Assessments were made through field visit to identify the major sources of post harvest losses within the existing supply chain;

2. Surveys (using interviews, questionnaires and personal observations) of growers, local sellers, whole sellers and retailers were made to assess problems/constraints and gather information/know approaches currently on use and planned for future to minimize post harvest losses of cabbage. Supply chains are mapped to identify and provide possible/appropriate system improvements.

Moreover, surveys were made by taking 30 cabbage samples (15 from wholesale level and 15 from retailer level) and storing for two days at home to consider the post harvest loss at the consumer level.

At first, 5 cabbage samples from each of the wholesaler and retailer levels were taken after removing the damaged part of the samples (any change in the availability, edibility, or quality of the food that prevents it from being consumed by people, which ultimately results either in complete wastage or monetary devaluation of the produce) and then the heads were labeled and weighed. After this, the samples were taken home and stored for two days (which is considered by this study as average storage time of the produce at the consumers level) in a simple home storage way. After two days of storage, the damaged and unwanted parts of the cabbage heads were again removed and then the heads were weighed. Hence, the weight loss of each sample was computed as the difference between the two measured weights; and average weight loss was calculated by dividing the sum of weight losses of each sample to the total number of samples. This procedure was continued for the second and third experiments; hence, total average post harvest loss at the consumer level was obtained by dividing the sum of the average weight losses at each experiment to the total number of experiments.

3.4. Data analysis

The data obtained from the field survey was analyzed using spreadsheet and, discussions and recommendations are made based on the results obtained. For data analysis, frequencies, averages and percents were used.

Post harvest losses assessment methodology of this study has considered the following points related to the handling and marketing of the leafy vegetable cabbage.

- Harvesting and production amount (to assess whether they are based upon market information and consumer preferences or not);
- Handling/storage mechanisms at each level (cleaning, shade, cooling, sanitation, pest management);
- Harvesting/buying and selling amount (to assess the PHL of produce); Transportation (time of transport, packaging methods/modes of transport used);
- Time length of the produce at the hand of each actor (to know the time needed for the produce to reach retailers/end users);

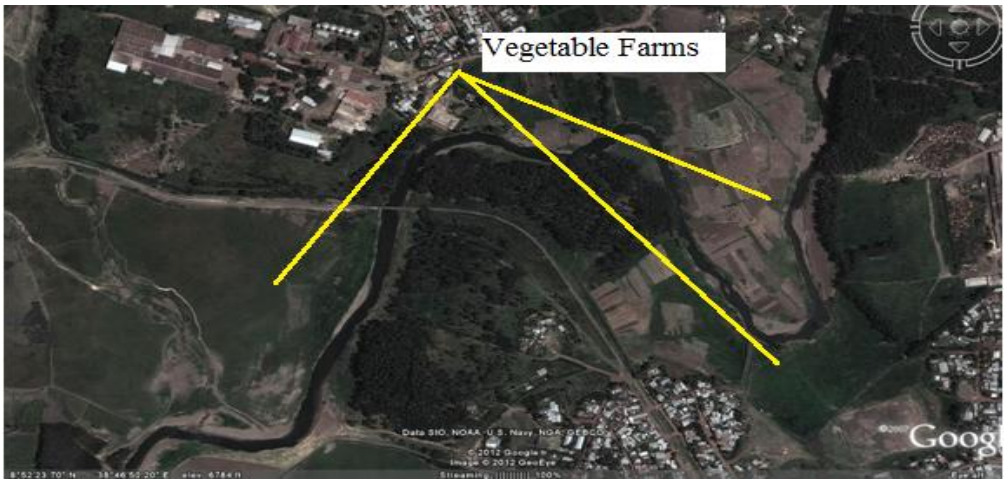


Figure 4: Google map of great Akaki River and its surrounding vegetable farm

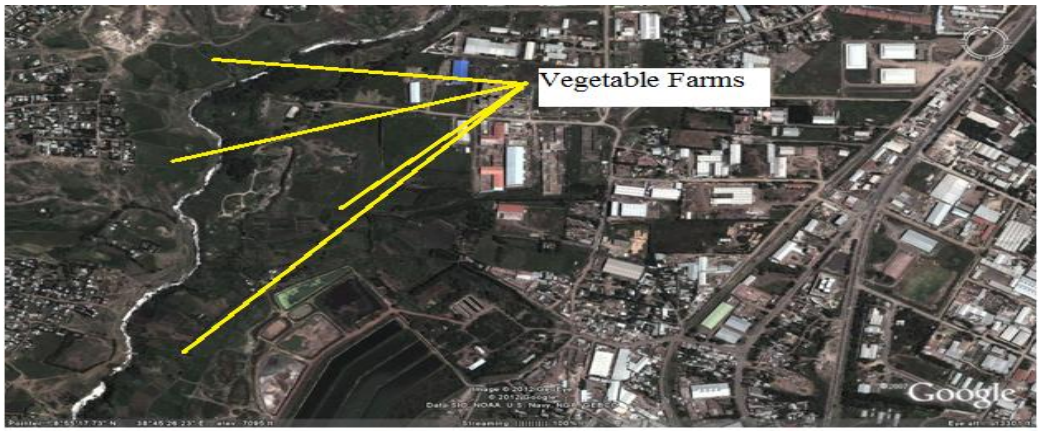


Figure 5: Google map of little Akaki River and its surrounding vegetable farm

4. Results

4.1. Respondents profile

The socio-demographic characteristics of the respondents at all levels (farms, local markets, wholesalers and retailer levels) were gender and education as follows.

General profile

The majority of the supply chain actors who participated in the survey were males, accounting for about 70.8% of the total number of respondents (Table 1). Wholesaling was male dominated profession. Only about 40.2% of the respondents have high school, university or college qualifications while the majority attain only primary education or lower (Table 2).

Table 1: Gender profile of cabbage supply chain actors (N = 72)

Supply chain actor	Male		Female		Total	
	N	%	N	%	N	%
Farmer	7	70	3	30	10	13.9
Local trader	3	60	2	40	5	6.9
Wholesaler	15	100	0	0	15	20.8
Retailer	26	61.9	16	38.10	42	58.3
total	51	70.8	21	29.2	72	100

Table 2: Educational background of cabbage supply chain actors (N = 72)

Education Category	Supply chain actor									
	Farmer		Local trader		Wholesaler		Retailer		Total	
	N	%	N	%	N	%	N	%	N	%
None	4	40	1	20	2	13.3	9	21.4	16	22.2
Primary	4	40	4	80	7	46.7	12	28.6	27	37.5
High School	2	20	0	0	5	33.3	17	40.5	24	33.3
University/Colege	0	0	0	0	1	6.7	4	9.5	5	6.9

Out of the 10 respondents at farm level, who were interviewed during the survey, 8 of them were individuals and the rest two were members of two unions. Out of the two unions, one union was females union (Cholle Mother's Vegetable Production Union) and the second one (Mekana Biruh Tesfa Union), which is union of both males and females. Those respondents are cabbage growers using irrigation water from Akaki River in around Akaki sub city of Addis Ababa.

Fifteen respondents were found in three purposefully selected wholesale areas and all interviewed. Those respondents were, 1 from Saries Vegetables and Fruits wholesalers and Retailers Union, 4 from Kerra Vegetables and Fruits Wholesalers and Retailers and the rest 10 from "Atikilt Tera", which is the main wholesaling area of the city of Addis Ababa. Moreover, 42 respondents from six different retail areas, Saries, Kerra, Atikilt Terra, Shola, Kazanchis and Bole each with seven respondents, were selected and interviewed.

Education improves supply chain actors awareness, adoption of technologies and use of other scientific loss controlling mechanisms. However, this study revealed that despite of their educational level, all the supply chain actors follow the traditional way of handling, transporting and storage mechanism of the produce throughout the supply chain; even they did not consider shade to reduce the moisture loss of the produce which is simple to provide at low cost. Moreover, it was observed that the participation of females is limited throughout the supply chain, where, wholesale level was male dominated.

4.2. Irrigation

The farmers in this study area grow different types of crops and vegetables in their farm at different seasons. Produce grown in one season may not grow in the next season. Hence, the farmers are not only cabbage growers but they grow different types of crops and vegetables.

The method of irrigation used by farmers for growing cabbage is by pumping/taking water from the nearby Akaki River using water pump.

Farmers grow different types of cabbage varieties, where, *'denmark', 'holland'* and *'monarch'* were found to be the most common varieties grown by most of the growers (Table 3). According to the information obtained from the growers, cabbage takes 3 months on average from planting to reach maturity.

4.3. Harvesting and handling

Cabbage heads are harvested when the heads reach full size and are firm and compact. The stem below the head is cut by leaving 2-3 wrapper leaves for protection. During the study some harvesting problems were observed, as harvesting was conducted mostly based on orders from wholesalers and local traders. When orders come late over maturity of the produce becomes a problem. In addition, since harvesting is conducted using labors employed by these traders, cutting of immature cabbage heads was observed at some farms, as this is often difficult to everyone. Moreover, according to the information obtained from the respondents (Table 4) and on-site visits, cabbage was sometimes harvested during the hot periods of the day, which is not recommended.

The farmers proved that determining the optimal time to harvest cabbage is often difficult, as a result, the decision to harvest is made just by simple observation and is based on overall appearance, such as, when the wrapper leaves are spread and the head is exposed and firm to touch. Generally, mature cabbage has good head formation, good weight in comparison to size and has a longer post-harvest lifespan than the immature one. All growers agreed that harvesting of cabbage should be done as soon as mature to prevent cracking of heads.

All farmers used ordinary knife to harvest cabbage. Harvesting was done by cutting the base of the cabbage head by leaving some wrapper leaves from protection. This was one good practice observed at farm level.

Table 3: Method and time of harvesting of cabbage in Akaki

No.	Sex	Description	Area of Farm (ha)	Variety Grown	Time to Harvest When Mature	Annual Average Quantity Produced (kg)	Selling Price / kg (birr/kg)
1	F	Cholle Mother's VPU	1	Denmark	Based on orders	35200	2.0
2	F	Individual	0.125	France	Based on orders	7040	1.8
3	F & M	Mekana Biruh Tesfa Union	1.25	Italy, France, Monarch	Based on orders	45760	2.6
4	M	Individual	0.125	Holland & Monarch	Based on orders	10560	2.0
5	M	Individual	0.5	Denmark	Immediately	21120	2.3
6	M	Individual	0.25	Holland	Based on orders	14080	1.8
7	M	Individual	0.25	Denmark	Immediately / Based on orders	12320	1.7
8	F	Individual	0.125	Denmark	Based on orders	8800	1.7
9	M	Individual	0.5	Holland	Based on orders	19360	2.3
10	M	Individual	0.25	Holland	Based on orders	12320	2.0
		Average	**0.44**				**2.02**

All supply chain actors do not have any previously recorded data on production, transportation, buying/selling and other activities. Hence, the annual average quantity produced by the farmers was obtained from their experience in previous production years and the study let farmers to respond to the questionnaire "*Annual average production*". The term "*average*" here is not to mean an average of obtained data, but it is just the value given by the respondents what they consider to be an average quantity produced per year. Moreover, the selling price here is the selling price during the survey time.

No different handling and storage mechanism (such as, ways to keep the temperature lower either by providing appropriate shelter or other prompt cooling techniques, ways to prevent the produce from animal and pest attack etc.), was observed at the farm level. The produce was filled in a sack and carried by shoulder to a central collection point with no any shed within the farm, and then loaded either in bulk to a truck to be transported to the wholesale area or fill in sack and loaded to a horse cart to be transported to nearby local market areas as shown in Figure 6.

Figure 6: Modes of transport for fresh cabbage from Akaki

4.4. Supply chain and post harvest loss of cabbage from Akaki to Addis Ababa

4.4.1. Supply chain of cabbage

Figure 8 shows the schematic diagram of cabbage supply chain from around Akaki to Addis Ababa where the number of intermediates involved was very small. In this supply chain, the transaction cost was small due to the reduced number of intermediaries.

Even though there are some farmers who collect and transport cabbage to the wholesale area, it is mostly collected at the farm and transported to the wholesale area by the wholesalers. Despite being small in amount, farmers also sell their produce to local

traders who supply cabbage to retailers and street vendors in Addis Ababa. Wholesalers sell cabbage to retailers, consumers, street vendors, hotels and restaurants (Figure 8).

The number of intermediaries participating within the supply chain was found to be small. As shown in figure 8, maximum flow of the produce is from farm to wholesaler and from wholesaler to retailers and then to consumers (farm-wholesaler-retailer-consumer flow). Either wholesalers by themselves or farmers directly transport the produce to the wholesale areas within short period of time.

The wholesale areas are open to every customer, that is, even consumers have an access to buy vegetables and fruits from the wholesalers. This has dual advantages; firstly, consumers can buy the produce with a reasonable price and secondly, there is loss of product at each intermediary, then, consumers direct access to wholesaler reduce the number of actors in between, hence, reduced post harvest loss of the produce.

It was observed that cash flow has reverse direction with product flow, while, information flow has the same direction with product flow (Figure 8). Moreover, as farmers have direct contact with wholesalers, local traders and retailers; the role of brokers is almost limited which helps farmers to get reasonable profit from their product.

Respondents made to respond the questionnaire, *"For how many time do you store the produce before selling to your customers?"* Most of the response obtained was "*less than one day*" and recorded in hours, except at the retailer level, which was "*more than 2 days*". Hence, the average time the produce stored at each level was calculated, thus, the produce stays at the farm for short period (8 hours), at wholesale level (16 hours) and at the local market level (9 hours).

From farm to local markets, the mode of transport used was horse cart. While, from farm to the wholesale area and from wholesale to retailers area, the modes of transport used were light truck and small vehicles (cars, pick-ups and minibuses) respectively (Table 4). The mode choice mainly depends on the availability of the mode and the amount of produce transported. Horse cart is available around the farm and transport the produce

fort short distance to local market at lowest price. Pick-up car cannot transport the produce from farm to wholesale at once as many produce as Isuzu truck.

Figure 7: Kerra vegetables and fruits wholesaling and retailers market

In answering, for the questionnaire regarding the time of harvest and transportation of the produce, 80% of the respondents in the Farm-Wholesale supply chain and 87% in the Farm-Local Market supply chain respond that the produce is harvested at the morning (5:30-9:30 am) (Table 4).

Moreover, 87% of the respondents in the Farm-Local Market supply chain respond that the produce is transported to the local market at day time (9:30am-5:30pm) while 84% of the respondents at the Farm-Wholesale supply chain respond it is transported in the late afternoon (5:30-7:00 pm). From wholesale to retailers, the produce is transported at the morning (Table 4).

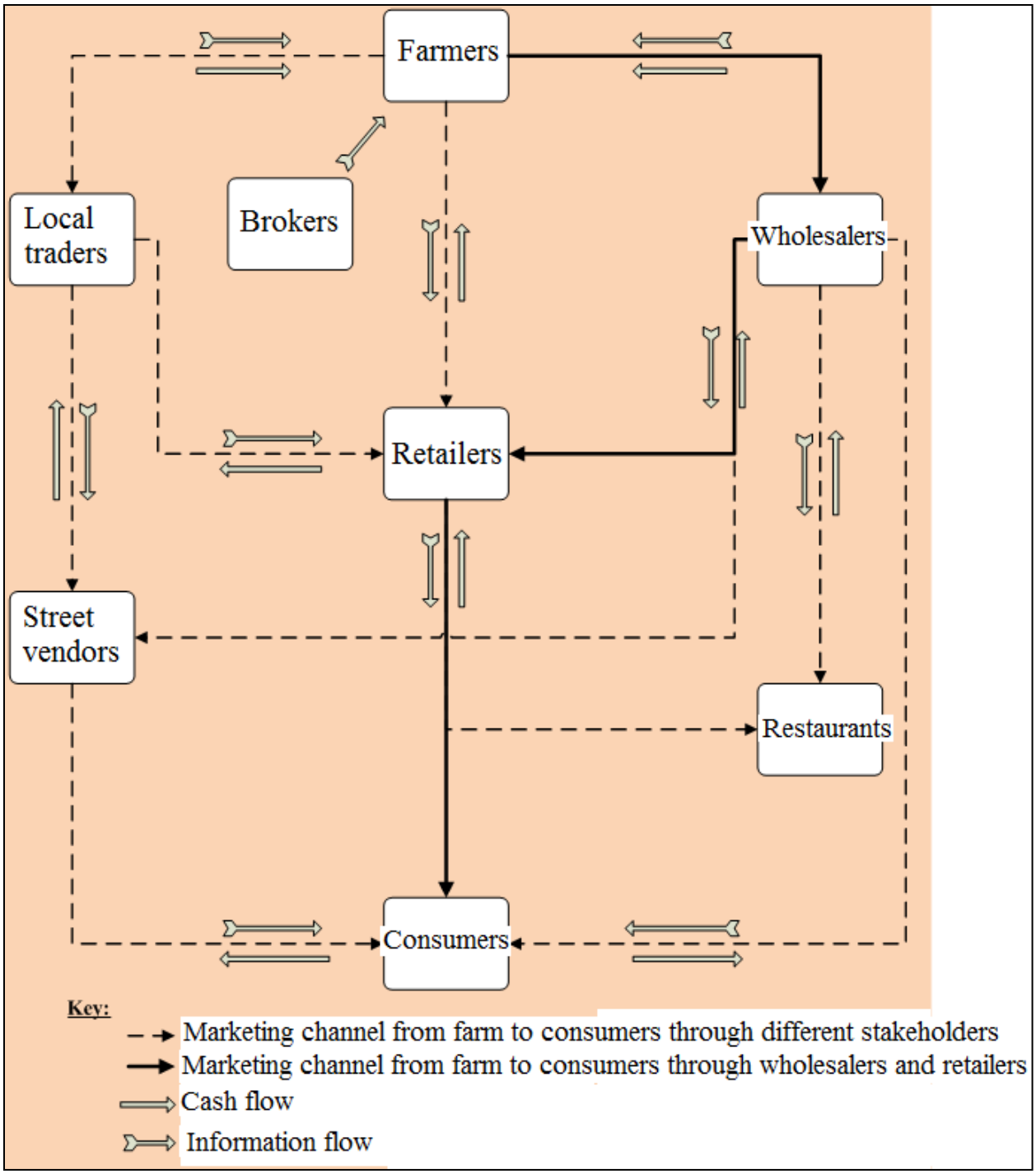


Figure 8: Supply chain diagram of cabbage supplied from Akaki

a) Packaging and transporting along the chain

No packaging material was used for cabbage from farmers to wholesalers where the produce was transported in unpacked (loose) form, which is locally called 'fisash'. From farmers to local traders and retailers, from local traders to retailers, and from wholesalers to retailers and street vendors sack was the most commonly used packaging material. From wholesalers to retailers crates were the second most commonly used containers.

Figure 9: Wooden box and plastic crates as cabbage packaging materials

Figure 10: Cabbage at the local market in Akaki

Table 4: Mode and time of transportation of cabbage within the supply chain (N = 72)

Supply Chain	Actor	Mode of Transportation				Harvesting Time			Transportation Time		
		Human Shoulder	Horse Cart	Car	Truck	Morning (5:30 - 9:30 am)	Day time (9:30 am -5:30 pm)	Late Afternoon (5:30 pm -7:00 pm)	Morning	Day time	Late Afternoon
Farm - Local Market	Farmer		10	-	-	9	3	4	6	8	1
	Local Trader	-	5	-	-	4	2	2	4	5	-
	Total (%)	-	100	-	-	87	33	40	67	87	7
Farm - Wholesale	Farmer	-	-	-	10	8	6	3	2	4	7
	Wholesaler	-	-	-	15	12	6	1	5	2	14
	Total (%)	-	-	-	100	80	48	16	28	24	84
Farm - Retailer	Farmer	-	3	8	-	9	2	-	9	-	1
	Retailer	-	-	7	-	-	-	-	7	-	4
	Total (%)	-	5.7	29	-	17.3	3.8	-	69.2	-	9.6
Local Market - Retailer	Local Trader	-	-	4	-	-	-	-	-	3	2
	Retailer	-	-	1	-	-	-	-	-	1	-
	Total (%)	-	-	10	-	-	-	-	-	8.5	4.2
Wholesale - Retailer	Wholesaler	-	-	7	3	-	-	-	9	1	-
	Retailer	-	-	42	8	-	-	-	42	3	-
	Total (%)	-	-	86	19	-	-	-	89.7	7	-

* Values are multiple response

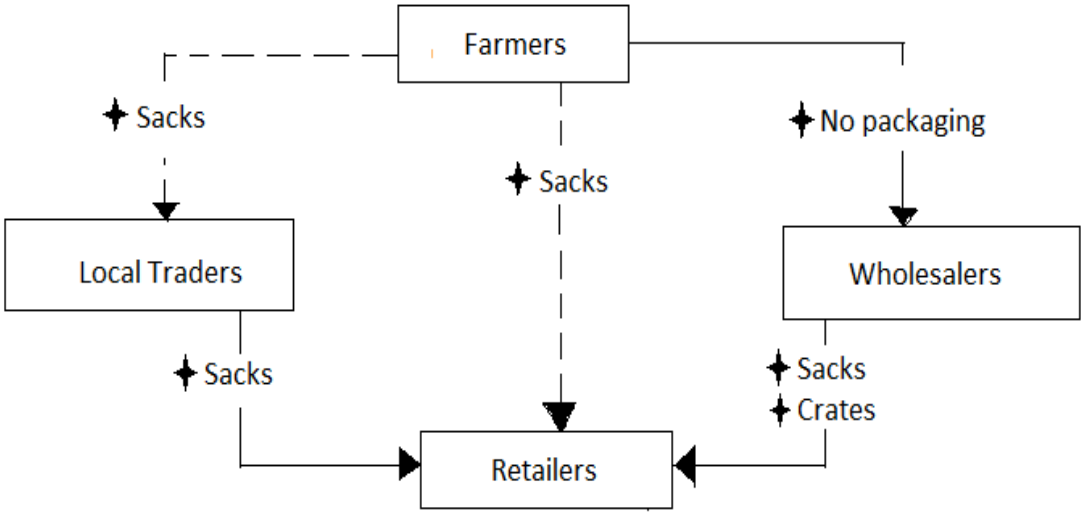


Figure 11: Main packaging materials for fresh cabbage from Akaki to Addis Ababa

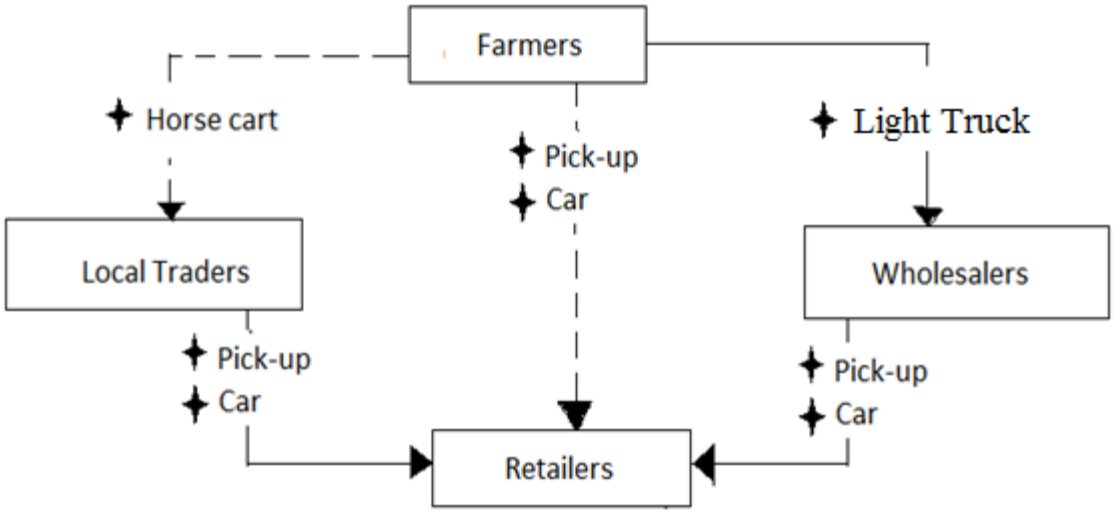


Figure 12: Mode of transport of fresh cabbage from Akaki to Addis Ababa

As shown in Table 4, 84 % of the respondents from farm and wholesale described that the produce is transported in the late afternoon (5:30-7:00 pm). This is the time where frequent traffic congestion is observed in different areas of the city and the Akaki-Saries-Kerra/Piazza main road (which is the direct route to the three wholesaling areas) in

particular. This leads to increase the transportation time length of the produce, hence, increase the post harvest loss of the produce due to continuous loading/mechanical damage and increased transportation temperature.

During transporting the produce from the farm to the wholesaling area, the mode of transport commonly used was Isuzu truck. Pick-up, horse cart, car, minibus etc. were also used by different supply chain actors to purchase cabbage from suppliers.

b) Information flow

Large shares of chain actors seek information on price but little on quality traits of cabbage. Farmers take the highest share of respondents who seek such information, and the need is reduced as the produce moves along the chain, but is still high among retailers.

Share of respondents who seek information on prices is higher than those who seek information on quality traits. They search for any sort of information related to price variation of the produce daily. For farmers, the most important sources of price information are other farmers and brokers, but local traders are also sources of information. All chain actors usually inquire information about cabbage price on a daily basis. Local traders, wholesalers and retailers usually obtain price information from other traders. As per the information obtained from the respondents, none of them uses mass media (TV, radio or any other) to obtain price or quality related information.

Retailers, unlike to price information; relatively give high value for quality trait than others. Most respondents consider freshness, size and hardness, and free of pathogens as the most important quality trait, while certification and other food safety considerations (free from fertilizer or pesticide residues) the least (Table 6).

Table 5: Actors who seek information on market price and quality traits of cabbage (N = 72)

Type of information	supply chain actor	N	Frequency	%
Price	Farmer	10	10	100
	Local Trader	5	5	100
	Wholesaler	15	12	80
	Retailer	42	20	47.6
Quality traits	Farmer	10	2	20
	Local trader	5	1	20
	Wholesaler	15	7	46.7
	Retailer	42	30	71.4

Table 6: Importance of quality traits assessment for cabbage (N = 72)

Quality Trait	Farmers	Local Traders	Wholesalers	Retailers
Freshness	5	5	5	4.5
Size	3.75	4	4	4.5
Hardness	4.5	3.4	4.5	4
Certification	1	1	1	1.5
Free from pathogens	2	3.25	3.5	4.5
Free from fertilizer and pesticide residues	1.5	1.7	1.5	2

* *Respondents ranked importance of quality traits on a scale of 1(not important at all) to 5(very important).*

c) Prices

The price of the produce greatly varies monthly, yearly and varies with quality. According to the information obtained from the farmers the average selling price of cabbage per kg dropped from 3.5 birr at the beginning of the cabbage production in January to 2.0 birr in March 2013 (the survey time). This was because of the quality reduction of the produce due to heavy rain and increased farmers' cabbage production.

The average price per kilo of cabbage at the wholesaling area was found to be 3.0 birr and at the retailer's level, it was 6.0 birr. However, this price varies from time to time depending on the supply and quality of the produce. Cabbage is a highly seasonal crop

with an oversupply during the dry seasons (winter and spring seasons) which are production peaks and undersupply during lean season (summer season) resulting in highly fluctuating prices. During the summer season, farmers have power to decide on the price, whereas during the dry season, price fluctuation is mostly on the hand of wholesalers and intermediaries.

4.4.2. Post harvest losses of cabbage in supply chain

I. Overview of post harvest losses

Main reasons for postharvest losses are disease infection and poor quality of purchased cabbage (Table 7). Almost all farmer respondents revealed that shortage of pesticide and heavy rain as main causes of losses, even though heavy rain is not a frequent phenomenon. For retailers, losses are mainly due to diseases, failure in selling all the produce and purchasing of poor quality produce. Wholesalers also consider damage during transportation and diseases as a major problem.

Table 7: Main causes for post harvest loss of cabbage (N = 72)

Reason of post harvest losses	Supply Chain Actors								Total	
	Farmers		Local traders		Wholesalers		Retailers			
	N	%	N	%	N	%	N	%	N	%
Poor storage condition	2	20	4	80	3	27	6	30	15	33
Damage during harvest	3	30			4	36			7	15
Damage during transportation					5	45	4	20	9	20
Poor packaging					4	36	3	15	7	15
Cannot sell all vegetables			1	20			14	70	15	33
Poor quality of purchased cabbage			2	40	4	36	12	60	18	39
Diseases	5	50	3	60	5	45	18	90	31	67
Others	3	30	1	20	2	18	8	40	14	30

∗ *Values are multiple responses.*

After an agreement is made between the farmer and the wholesaler, most of the time the wholesaler harvests the produce using its own labor to the desired amount, collects and stores it temporarily in the farm. Firstly, the wholesaler selects quality and matured cabbage, cuts using a knife and then collects it to a sack to be carried by labor to the temporary storage area. The produce was stored at the farm level in a central collection point in a condition completely exposed to sun (i.e. no shading was used).

Figure 13: Collecting and temporary open-air storage of cabbage at farm level

Figure 14: Open-air storage and its moisture loss effect on cabbage at the farm level

As shown in figure 13, the man is collecting the cabbage to a temporary open-air storage that is completely exposed to sun light, and a truck is waiting to transport the produce to

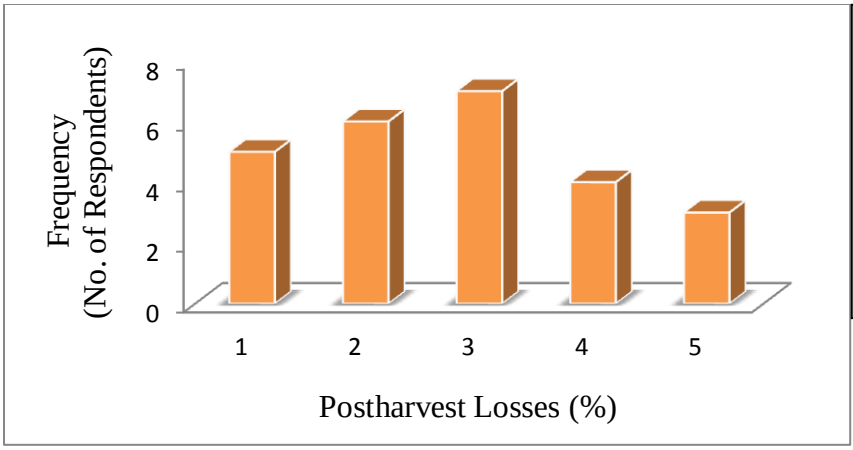
the wholesaling area. Most of the time, the produce is transported to wholesale area directly after being collected.

The time of storage at farm level is mostly less than half a day (8 hours on average). However, when excess produce is harvested, it is stored sometimes in open air for the whole day at farm (Figure 14). Even though this is a rare phenomenon, it leads to moisture loss of the produce and contributes to post harvest loss increase of the same.

As per the information obtained from the respondents (farmers and wholesalers) at the farm level, the average postharvest loss of cabbage is 4.0 % (Figure 15). The average postharvest loss at the wholesale, retailer and consumer levels is found to be 29.5 % (Figure 16), 17.6 % (Figure 17) and 7.8 % (Figure 18) respectively.

The Losses at farm, wholesaler and retailer levels were obtained from the respondents by making them to answer the questionnaire *"Is there any loss of the produce bought before it is sold? If "YES", how much could be the loss on average (%)*?" While at the consumers level these losses were obtained by conducting three experiments on a total of 30 cabbage samples obtained (15 from wholesalers and 15 from retailers) as weight loss between the weight of trimmed cabbage during buying and weight of trimmed cabbage after two days of home storage. The average percentage losses at each experiment were obtained by dividing the sum of average percentage losses to the total number of cabbage samples in that experiment (Figure 18); and the average post harvest loss of the produce at the consumers level was obtained by dividing the sum of average post harvest losses at each experiment (both wholesale and retailers) to the total number of experiments.

Chebyshev's Theorem was used to examine how the data obtained at the farm, wholesale and retail levels scattered away from the sample means; sample standard deviations was calculated and intervals was formed by adding and subtracting two standard deviations from the means . According to Chebyshev's Theorem, for any numerical data set, at least 75% of the data lies within two standard deviations of the sample mean ($x \pm 2s$) [29]. It was found that the data were less variable and lie within the intervals (Figures 15 to 17).

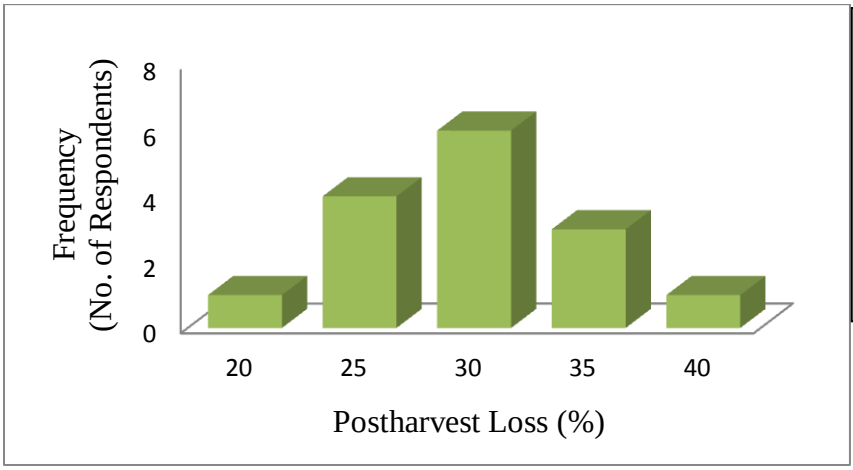


Sample Mean (x-) =4.0

Sample Sta. Deviation (s) = 1.8

x ± 2s = (0.4, 7.6)

Figure 15: Post harvest loss of cabbage at farm level

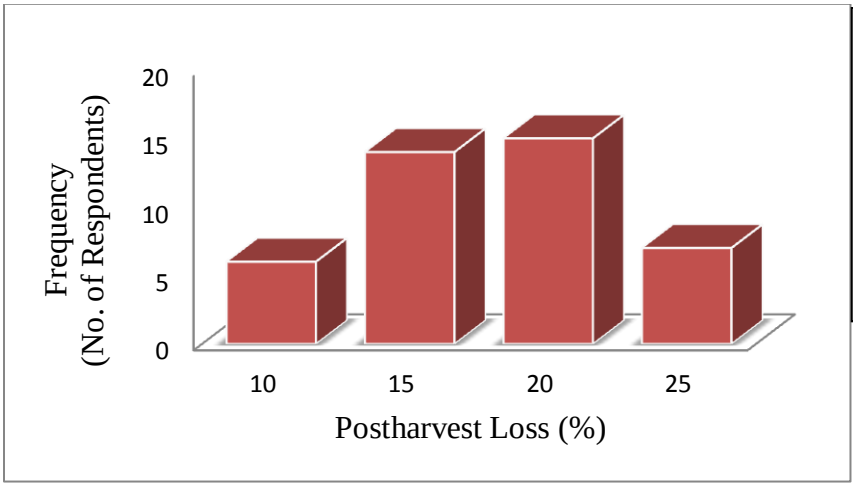


Sample Mean (x-) =29.5

Sample Sta. Deviation (s) =5.16

x ± 2s = (19.3, 40)

Figure 16: Post harvest loss of cabbage at wholesale level



Sample Mean (x-) = 17.6

Sample Sta. Deviation (s) = 4.7

x ± 2s = (8.3, 27.1)

Figure 17: Post harvest loss of cabbage at retailer level

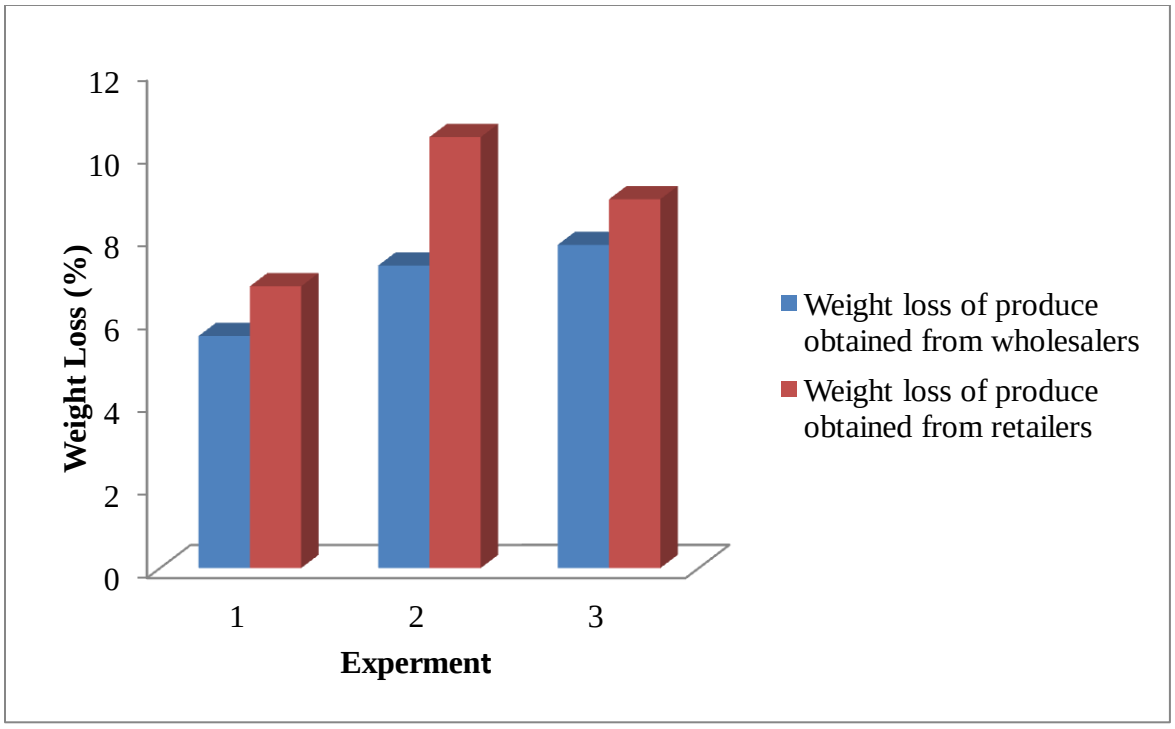


Figure 18: Post harvest loss of cabbage at Consumers Level

The weight losses (post harvest loss) of cabbage at consumer's level after two days of storage, in all of the three experiments, were higher for the samples obtained from retailers than these obtained from wholesalers (Figure 18).

Note that, the weight loss calculated during measurement includes physical damage, damage due to disease infection, wilting of the cabbage head that change the physical appearance and reduce the quality so that reduce the edibility and reduce market value of the produce and weight loss of the produce due to moisture loss.

II. Sources of post harvest losses of cabbage

There are a number of factors, which increase the post harvest losses of cabbage within the supply chain. These factors are broadly categorized in to two, namely, pre harvest factors, which are factors at farm before harvest but contribute in increasing the losses after harvest, and post harvest factors.

Effect of pre-harvest factors on postharvest quality of cabbage supplied from Akaki

There are numerous factors affecting post-harvest quality of the produce, from the soil in which the crop is grown to the handling of produce when it reaches the end users. Pre-harvest production practices may seriously affect post-harvest returns. Like other plants, cabbage needs a continuous supply of water for photosynthesis and transpiration. Damage of the vegetable can be caused by too much rain, which can lead to head crack and decay; by too little water; and by irregular water supply, which can, for example, lead to head cracks again [6, 11].

According to the information obtained from growers and through personal observation at the farm level, the following pre-harvest factors were found to be the main reasons for post harvest losses of the produce.

a) Lack of scheduled watering: watering has a great effect on the maturity and quality of cabbage. If watering activity is not done frequently in a well-scheduled manner, the cabbage is lost by splitting. Moisture fluctuations during heading will cause maturing heads to split open because of excessive water pressure created in the heads.

   During the study, it was observed that many matured heads were split open and non-matured ones were damaged due to heavy rain.

b) Shortage of pesticide: Most of the farmers said that they face shortage of pesticide and this promotes the spread of fungal, bacterial disease and insect pests. As a result, the pre-harvest and post harvest losses of the produce increases.

c) Heavy rain: Split open and highly damaged produce was observed at the farm due to heavy rain (Figure 19). This increase losses of the produce after harvest as the damaged and decayed part of the produce is discarded before sell.

Figure 19: Damage of cabbage due to heavy rain at farm in Akaki

d) Use of polluted irrigation water: The only source of irrigation water for the farmers is the Akaki River, which is highly polluted. This also increases the post harvest losses as it promotes the growth of fungal, bacterial, insect pests and other pathogens. This study revealed that most of the farmers have no idea whether poor quality of the irrigation water could be a reason for increasing the post harvest loss of the produce.

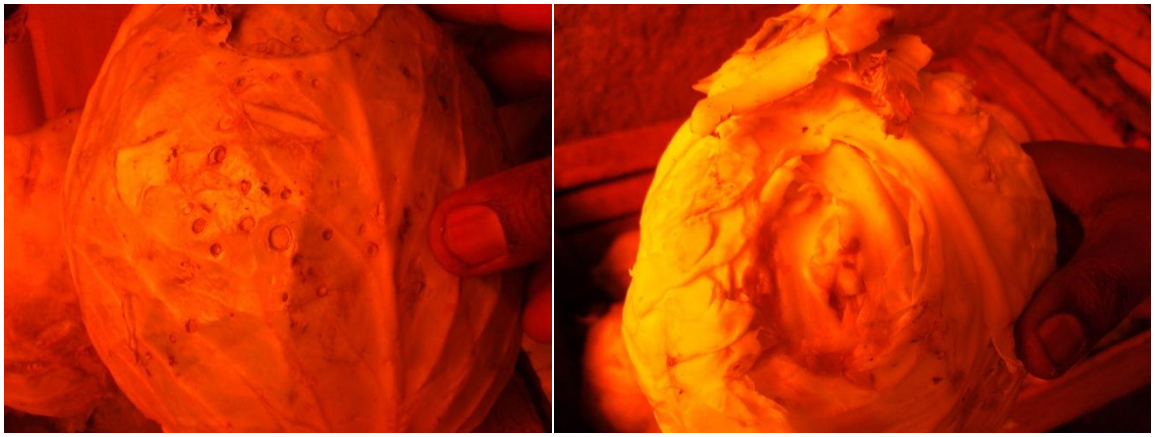


Figure 20: Damage of cabbage due to insect pests and pathogens

e) Degree of maturity and harvesting of cabbage: Cabbage can be harvested any time after the head develops. Cabbage head is cut when it is solid (firm to hand pressure) but before it cracks or split. Cabbage for storage must be firm, mature and free of injury from insects or diseases. In this study, some problems related to degree of maturity were observed, even though to a minimum amount. During harvesting some

immature cabbage heads were harvested and also cracked heads were observed at the farm as a result of over maturity. But no problem was observed related to the method of harvesting (cutting), as harvesting was usually done by cutting the base of the cabbage head using a knife, which is a good practice compared to the old practice of uprooting the whole plant or breaking the head by hand.

Effect of post harvest factors on postharvest quality of cabbage supplied from Akaki

The following factors were found to be the main reasons for increasing the post harvest loss of cabbage produced and supplied from around the Akaki River.

a) *Mechanical damage*: Damaged or injured cabbage promotes the growth of fungal and bacterial pathogens and thus increases the post harvest loss. Due to the damage during loading/unloading and transportation, relatively greater losses of the produce were observed at the wholesale area.

b) *Poor Storage conditions*: Storage conditions like shelter, temperature, humidity etc. greatly affect the quality and shelf life of cabbage. Good storage conditions protect the produce from excessive moisture loss and growth of pathogens. However, it was observed that no shelters were used at the farms and local markets level even though the cabbage was stored temporarily for short time. At some retailers poor sheltering and mixed storage of cabbage with other vegetables and fruits was observed (Figure 23). As per the information obtained from the respondents at the retailers' level, the average shelf life of cabbage supplied from Akaki is as short as five days. It spoils easily in short time and this was found to be a great problem for them.

Figure 21: Cabbage at the wholesale area in Saries (left) and Atkilit Terra (right)

Figure 22: Unloading of cabbage at wholesale (left) and weighing sample at consumer level (Right)

Figure 23: Storage of cabbage at retailers' level

Other quality degradations, such as change in color and spoilage of cabbage, were observed at the retailers' level (Figure 24).

Figure 24: Blackish and spoiled cabbage at the retailers' level

To conserve the quality of the produce, no any special storage facility was employed at all stages of the supply chain.

4.5. Route Selection

To reduce the post harvest loss of the produce, selecting the best route in terms of distance of transportation, traffic conditions and road surface conditions was found important. Distance of transportation and road traffic conditions have direct relationship with the time length of transportation and road surface condition with the mechanical damage of the produce during transportation.

To select the shortest route in terms of distance, two alternative routes for the Akaki-Kerra route and four routes for the Akaki-Piazza (Atikilt Terra) route (Figure 25) were selected and compared based on the length of the roads between ends (Table 8). The distances of the routes were measured from Google map.

Akaki-Saries-Kerra and Akaki-Saries-Stadium-Piazza were found to be the shortest routes, while, the Akaki-Saries route is the only main route for transporting the produce from farm to the Saries Vegetables and Fruits Wholesale and Retail Market (Table 8).

Table 8: Route comparison for produce transportation from farm to the two wholesale areas

Origin-Destination (Farm-Wholesale)	Route No.	Transportation Route	Distance (km)	Best Route
Akaki-Saries	1	Akaki-Saries	12.65	1
Akaki-Kerra	2	Akaki-Saries-Kerra	15.48	2
	3	Akaki-German Sq.-Kerra	18.8	
Akaki-Atkilit Terra	4	Akaki-Saries-Stadium-Piazza	20.8	4
	5	Akaki-Saries-Kerra-Mexico-Piazza	21.5	
	6	Akaki-German Sq.-Teklehaymanot-Piazza	24.3	
	7	Akaki- German Sq.-Kerra-Mexico-Piazza	24.89	

The selected routes were asphalt paved main routes and observed had good surface conditions from that may cause vibrations and other mechanical impacts to the produce. Moreover, since the transportation of the produce from farm shall be carried at night or in the early morning and the roads are almost open at these times, the impact of road traffic condition was ignored.

4.6. Supply of discarded cabbage for users

At the wholesale area, large part of cabbage, including the wrapper leaves and the damaged part was discarded before sell. Some of this discarded cabbage part was collected in sack (Figure 26) and sold to traders who supply for consumers. Some of this is used for personal consumption and for animal feeding, especially cattle.

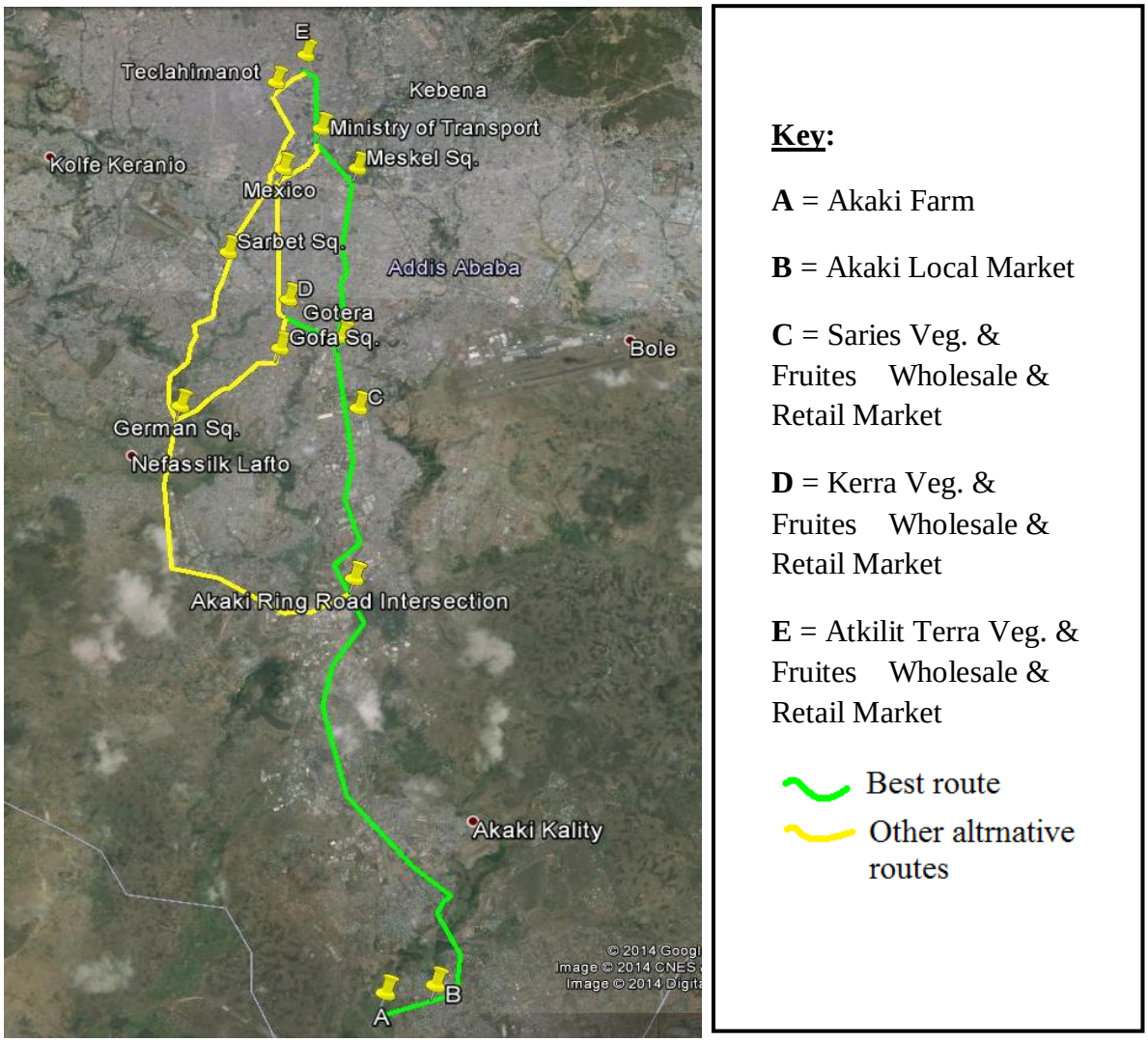


Figure 25: Transportation routes of cabbage from farm to the three Wholesale areas

Figure 26: Discarded cabbage collected in sack for sell around Atikilt Terra

5. Discussion

Majority (60%) of the supply chain actors have only primary or lower educational background. It was observed that trainings for the supply chain actors are required at each stage to improve their pre-harvest and post harvest activities, so that, they can have proper understanding concerning to the causes and natures of post harvest losses, preservation techniques, transportation methods and effective marketing systems. During conducting the study, it was observed that farmers do not consider the poor quality of the river water could have a great impact on the post harvest quality of the produce. On the other hand, when retailers made to answer to the question why the cabbage supplied from Akaki has shorter storage life, almost all of them replied that the main reason could be the poor quality of the irrigation water from the Akaki River. This is because, from their daily experience, they able to compare the produce with the produce supplied from other areas.

Retailers, unlike to price information; relatively give high value for quality traits than others since the quality of the produce has direct relationship with its shelf time and retailers store the produce relatively for longer time, hence, shelf time is critical for them and that is why they give high value for quality traits compared to other supply chain actors.

Respondents ranked (from the highest to lowest) causes of post harvest loss of cabbage within the supply chain as disease infection, poor quality of purchased cabbage, unable to sell all the produce and poor storage condition respectively. But, this study consider poor storage condition (higher storage temperature and poor sheltering) and mechanical damage (during transportation and during loading/unloading) as the most causes of loss, as these are the most contributing factors for disease infection, reduced quality and lower shelf time of the produce.

The total post harvest loss of cabbage supplied from Akaki was found to be 58.9 %, which is too big. The post harvest losses at wholesale and retail stages constitute the

higher proportion of the post harvest loss. Actually, this does not mean the sources of the post harvest losses are in these two stages, but it is also the result of cumulative effects from the upfront levels. On the other hand, using polluted irrigation water and failing to promptly store the produce in a place with appropriate shelter at the farms level had an impact on increasing the post harvest losses of the produce at the retailers' level. During measuring the post harvest losses at the consumer level, it was relatively higher for the samples obtained from retailers than that of wholesalers (Figure 18). This may be as a result of extended storage of the produce at the hand of Retailers and, hence, deteriorates easily with time.

Higher temperature (both during transportation and storage) greatly affects the quality and reduces shelf life of the produce. As a result, harvesting and transportation of the produce should be done at cooler periods of the day (at night or early morning) [16]. Cabbage should be put in baskets or well-ventilated picking containers and should be taken immediately after harvest out of field or to a well-ventilated shaded area for packing and transport [20].

However, this study found that harvesting was carried at morning, but transportation to the wholesale area was carried at the late afternoon. This means the produce should have to be stored the whole day in a condition exposed to sun at the farm where there is no any shad. This is also a great problem, since such direct exposure of cabbage to the sun increases the temperature of the produce, which promotes bacterial growth, and increase moisture loss, which jointly increase the post harvest loss of the produce. It is simple and economical to provide a temporary packing shade/station from wooden poles and a sheet of other materials (metal, sack or plastic etc.) at the farm level to prevent such problems, though, none of them considered it.

Moreover, similar problem was observed at the retail level that the shelters used were not enough to protect the produce from direct sunlight, as the shelters protect during the morning but they didn't in the afternoon or vise versa.

Mechanical damage of cabbage was higher when it was transported in bulk due to increased self-weight, vibration and damage during loading and unloading. Cabbage in jute bag had higher mechanical damage due to high loading and vibration compared to wooden box and crates. Moreover, during transportation good ventilation should be provided to the produce to keep the storage temperature lower [3]. The major cause for postharvest losses is due to use of improper packaging during the transportation, and this transport loss of vegetables can be reduced from 20-30% to 5-7% using safe packaging. Loss of produce firmness was significantly higher of vegetables transported in sacks compared to plastic crates. The use of plastic crates reduced the transport loss of cabbage by 5.8%, and also preserves the quality of produce during post production handling [30].

This study revealed that most of the produce was transported to the wholesale area, where no packaging material was used. Firstly, when loading the cabbage at farm, the cabbage head was thrown from ground one by one up the truck and this will damage the produce. Next, as the produce was loaded in bulk, hence no ventilation (help dissipate excessive field heat and respiration heat), and increases the transportation temperature. Moreover, this also increases bruising and other mechanical damages of the produce due to continuous loading of the produce one over the other and due to excessive movement or vibration. Finally, the same problem as during loading, there is mechanical damage when they unload the produce at the wholesale area.

As described before it is possible to reduce the post harvest loss of vegetables from 20-30% (average 25%) to 5-7% (average 6%), hence, by 19% using safe packaging during transportation only. Moreover, by using plastic crates or wood box during transportation instead of poly-sacks the post harvest loss can be reduced by 5.8 % despite of the length of transportation, and the reduction in loss could be highly increased by using these packaging materials instead of loose transportation.

Considering the time length during transportation, it has also a great impact on maintaining the quality of the produce. This time length depends on both the origin-destination distance between the two points (Farm and Wholesale areas) and the traffic

condition of the roads during transportation. It is obvious that the more time spent during transportation, the greater the post harvest loss of the produce will be due to mechanical damage (continuous self-loading of produces one over the other, as the cabbage was transported in bulk) and increased transportation temperature.

Transportation of the produce should be, and this study recommend also, carried at night or during early morning, hence, can reduce the transportation temperature and reduce the travel time, as the roads are open during these times. When traveling during daytime from Akaki to Piazza through the shortest route (Akaki-Saries-Stadium-Piazza which is around 20.8km) that is the longest route to reach wholesale area compared to Saries and Kerra, sometimes, it may take from 80-90 minutes (assuming average speed of 15 km/hr). Nevertheless, shifting the travel time from daytime to night or early morning (before 7:00 am) can reduce the travel time to 20-25 minutes (assuming an average speed of 50-60 km/hr), which is almost four times.

According to the information obtained from the respondents at the retailer level, the shelf life of cabbage supplied from Akaki is as lower as five days. At 28, 24, 10 and 4^{o}C storage temperatures, cabbage can be stored for 4, 8, 12 and 18 days respectively [15]. On the other hand, taking Addis Ababa's maximum air temperature (24^{o}C) as storage temperature, the produce should have stored for 3 days more. Moreover, by keeping the storage temperature as lower as 10-15^{o}C (on the range of Addis Ababa's average temperature), the shelf life of the produce can be doubled, hence, significantly reduce the post harvest loss.

This lowering of storage temperature can be achieved by providing good ventilation, good shelter, increasing room height of storage area, avoiding heat generating materials and activities (like using heat absorbing building materials rather than using metal sheets and avoiding fire and others that can increase the room temperature etc.) and spraying cold water around the storage area etc.

6. Conclusion

During harvest, cabbage was collected and transported by human to a temporarily collection points until it is loaded to a truck or horse cart to be transported to the wholesale local market areas. The production area is found on the southern periphery of the city of Addis Ababa, and the distance of transportation is short and the road is paved (except the access road from the highway to the farm, which is short). This helps in reducing mechanical damage and injury of the produce due to vibration and continuous self-loading as it was mostly transported in bulk. Moreover, the numbers of intermediaries participating in the supply chain were found to be small which is considered to be good. This helps in reducing the quality deterioration/loss of the produce that could be occurred at each level and promotes fair profitability of all the supply chain actors.

In the supply chain, the postharvest loss of the produce was found to be the highest at the wholesalers' level, which is 29.5 %. This was as a result of the cumulative effects of pre-harvest factors (such as irrigation problems, shortage of pesticides, etc.), which affect the overall appearance and quality of the produce, and postharvest factors due to moisture loss, mechanical damages during transportation and disease infection, etc.

The following factors were found to be the causes for the post harvest loss within the supply chain for the leafy vegetable cabbage supplied from Akaki:

- poor quality of irrigation water,
- over production and failing to harvest on time,
- mechanical damage during transportation (failing to use appropriate packaging materials),
- poor/no sheltering,
- transporting of the produce during hot periods, and higher transportation and storage temperature,

- diseases infection and failing to sell the produce on time

Even though, it may be difficult to improve the quality of irrigation water, losses of the produce at each supply chain level due to the above reasons can be avoided or reduced significantly with no or minimum cost. Therefore, to minimize shortage, maintain the quality of the produce and raise the profitability of each supply chain actor, providing attention to the causes, natures of post harvest losses of the produce and their controlling mechanisms is vital.

The following points are found to be solutions, which are considered simple and practical to be applied by the supply chain actors. These are:

- farmers/wholesalers should harvest the produce on time when it is matured enough, but should avoid harvesting of the immature one;
- use of appropriate packaging materials, such as, wooden box and plastic crates during transporting the produce from farm to local markets, wholesalers and retailers;
- providing appropriate shelter at all storage areas, to protect the produce from direct sun light and keep the storage temperature lower. During harvesting, the produce should be promptly collected to a collection point with appropriate shade;
- harvesting and transportation of the produce during cooler periods of the day (during the early morning or at night) and through the shortest route possible;
- creating hygienic storage area;
- avoiding infected produce from the mass to keep others safe; and
- keeping the storage temperature as lower as possible.

7. Recommendations

To reduce the post harvest losses of cabbage produced around the Akaki River, stakeholders should better consider the following points:

a) Demand based production of the produce: farmers should be wise enough in growing cabbage. If cabbage market is good one season, most of the farmers change their farm from growing of other vegetables to cabbage the next season and this sometimes results in over production of the produce hence price drops and loss increases. Therefore, demand based production and predicting future market is recommended as one season market may not work for the other season.

b) Harvesting, handling and storage of fresh produce: harvesting and transporting during cold weather followed by cold storage is effective method of prolonging the postharvest life of fresh produce. It maintains the quality of cabbage by reducing growth of pathogens, respiration rate, ethylene production and moisture loss. Therefore, harvesting and transporting activities should be done during cold weather either in the early morning or at night, and the storage temperature should be kept as lower as possible.

c) Avoiding loose transportation of the produce and using appropriate packaging materials: Vibration, impact of high bulk load during transportation and injury during loading and unloading results in physical damage of the produce. Therefore, appropriate packaging materials like wooden/plastic crates should be used during transportation of cabbage from farm to the end users.

d) Providing proper shelter and ventilation at storage area: poor shelter was one of the main problems observed during conducting this study. At farms and local market levels, no shelter was used while at some retailer levels poor sheltering of the produce was observed. This increases the respiration rate, loss of moisture and promotes the growth of pathogens. Providing of shelter costs minimum but failure to provide that cost a lot. Thus, all supply chain actors should give attention to provide

adequate shelter for the produce. Shade should be provided over harvested produce, packing areas, for storage areas and for transport vehicles.

e) Hygiene: the storage area should be clean and ventilated.

f) Avoiding or taking care of mixed storage: mixed storage of cabbage with other fruits and vegetables may reduce its shelf life. Since some fruits and vegetables produce ethylene which reduce the storage life of cabbage, care should be taken when avoiding of mixed storage is difficult.

g) Adequate supply of pesticide: Insect pest problems during the growing season can also affect postharvest quality. Visible defects on the vegetable surface caused by insect feeding can have a negative effect on the appearance of the produce, thus decreasing its appeal to consumers. Feeding injury on vegetables by insects can lead to surface injury, creating entry points for decay organisms and increasing the probability of postharvest diseases. Concerned government and non-government bodies should help the growers in supplying sufficient pesticides as this was observed as the problem of most growers.

h) Maintaining the quality of irrigation water: It is known that the quality of irrigation water greatly affects the quality of the produce. The water used for irrigation by all growers is the polluted water from the Akaki River. Thus, the city government should give attention to the quality of the river water as much as possible, to make it safe for irrigation.

Limitations and constraints:

This study did not able to estimate fully the post harvest losses of cabbage, due to different reasons, at each level of the supply chain, while this was broad and needs higher financial support and more time. The amounts of losses estimated in this study were obtained through interviews and questionnaires. However, the reliability of the estimation could be higher if continuous follow up of the produce were made starting from the farm to table. To use this system you need to have labeled representative cabbage samples at farm and these samples should be transported with the cabbage population; hence, you follow up these samples throughout the supply chain and measure the losses at each stage, while such things need good financial support.

Therefore, for the future detail research assessments should be done to identify and quantify the post harvest losses of the produce at each supply chain level due to a specific problem (temperature and relative humidity, poor quality of irrigation water, disease infection, mechanical damage, etc.).

Another challenge in conducting this thesis work was some respondents' carelessness and lack of interest in providing relevant information as this is common problem in such activities. At the retailers' level, some respondents were not willing to respond for some questions in the questionnaire and to have evidences (such as photo).

"It is important not only to grow more, but also to maintain the quality and save the losses of what is grown"

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Appendix

Definition of terms

Supply chain management (SCM): is the process of planning, implementing and controlling the operations of the supply chain to satisfy customer requirements as efficiently as possible. It includes all activities related to coordinating and integrating the flow of product, information and finance from point of origin to point of consumption.

Postharvest: The postharvest sector includes all points in the value chain from production in the field to the food being placed on a plate for consumption. Postharvest activities include harvesting, handling, storage, processing, packaging, transportation and marketing.

Postharvest loss (PHL): It is the loss of edible part of a produce after being harvested because of incorrect stage of produce maturity, water loss, extreme temperatures, physical damage, contamination by pests and market competition, etc.

Farmers (growers): Are those who produce the vegetables and fruits at the farm site.

Wholesalers: Are those who sell goods in large quantities to be retailed by others.

Retailers: Are those who sell/distribute goods to the end users or consumers.

Local traders: are those who buy the produce from farmers and supply it to retailers, 'gulitis' and consumers

Consumers: are end users of the produce

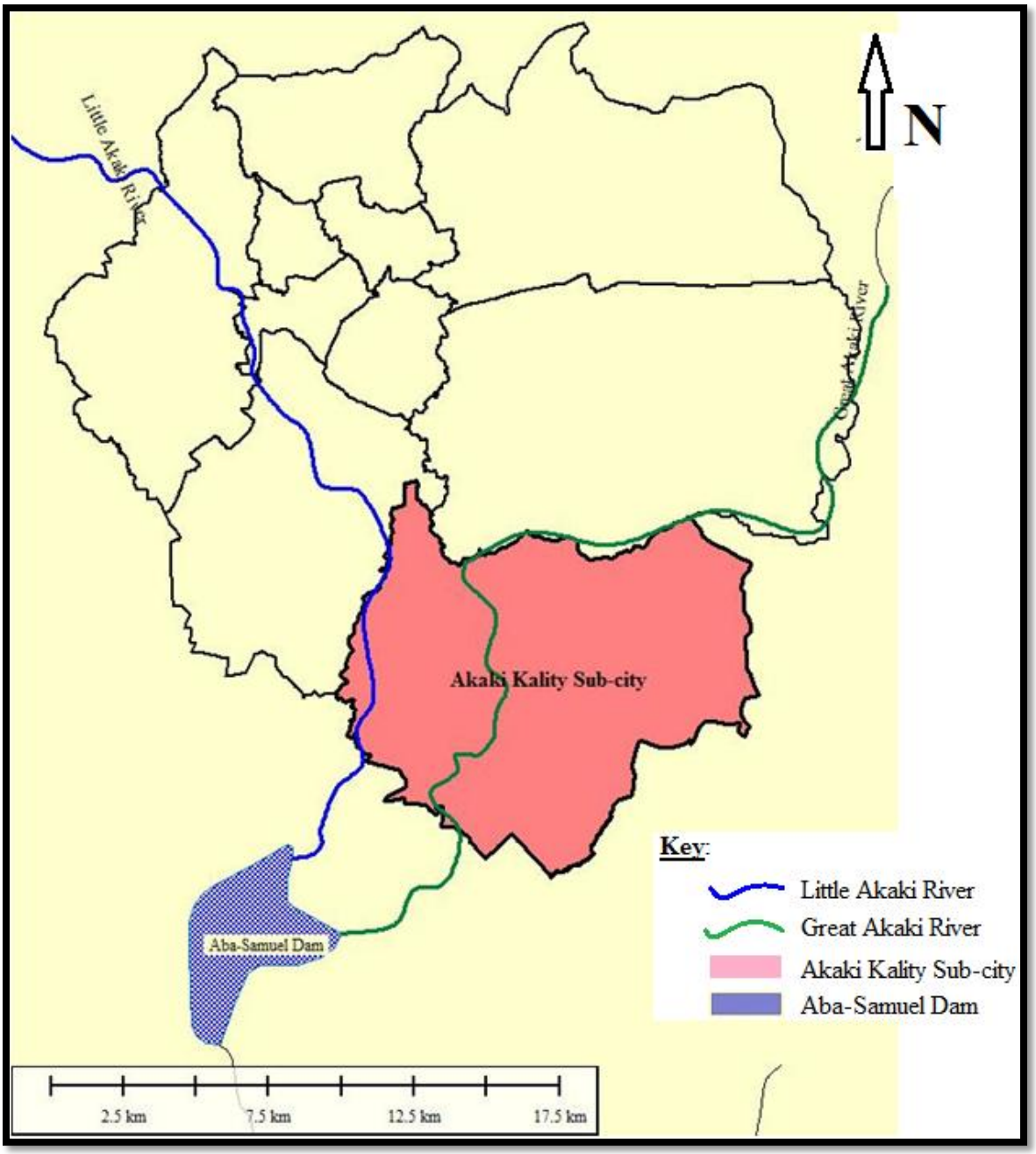

Figure 27: Flow of Akaki Rivers to the Aba-Samuel Dam out of Addis Ababa

Questionnaire formats

I. Questionnaire concerning PHL of cabbage at farm level around Akaki River

- Surveying Date:_____
- Gender : Male ☐ Female ☐
- Educational Background:

  None ☐ Primary ☐ Secondary ☐ College / University ☐
- Area of Survey Conducted:_____
- Varieties Grown:_____
- Growing Season: _____
- Cultivated Area (ha):_____
- Annual Average Production (kg):_____
- Annual Average Sales (Birr): _____
- Price per kg: _____

1. What kinds of pre-harvesting factors can increase the post harvest losses of cabbage?_____

   _____
2. How do you know the maturity of cabbage whether to harvest or not?

   _____
3. What method of harvesting/cutting mechanism do you use?

   _____
4. After harvesting how do you transport the produce to your storage/distribution area? _____
5. What method of storage do you use in your farm? _____
6. After harvesting the cabbage, for how many days do you store at farm before it is sold to your customers?

   Less than 1 day ☐ 1- 2 days ☐

   More than 2 days ☐

7. Is there any loss of the produce before it is sold? YES. ☐ NO. ☐
8. If your answer for Question number "3" is 'YES', how much (%) could be the loss? _____ _____
9. For what purpose do you use the loss at your farm? _____
10. During storage at farm level (observational):
    - Ventilation: Good ☐ Medium ☐ Poor ☐
    - Shelter: Sufficient shelter ☐ Poor shelter ☐ No Shelter ☐
    - Mechanical damage, during loading/unloading and do to self-weight of the stored produce: Significant ☐ Not significant ☐
    - Loss due to pests: Significant ☐ Not significant ☐
11. At which level do you think the loss of the produce is higher?
    During harvesting ☐ During transporting ☐ During storage/handling ☐
12. What is the packaging method used?

    Sack ☐ Wood box ☐ Metal ☐ Plastic ☐

13. To whom do you supply your produce directly?
    Consumers ☐ Retailers ☐ Wholesalers ☐
    Local assemble market ☐
14. What means of transport is used for supplying the produce to market?_____
15. Time of transportation: Early Morning Day Time Night
16. Communication/Information ☐ ☐ ☐
    - Obtaining Price Information: Daily ☐ Weekly ☐ Monthly ☐
    - Source of Price Information: Other farmers ☐ Collectors ☐ wholesalers ☐ Retailers ☐ TV/Radio ☐
    - Need to get information on quality traits (Rank 1- 5, where 1list and 5 highest)
      Freshness ☐ Size ☐ Grading ☐ Firmness ☐
      Packing ☐ Certification ☐ Free from pesticide/fertilizer ☐
17. Have you any problem/challenge within the supply chain?_____

II. Questionnaires Concerning PHL of Cabbage at Retailers Level

- Surveying Date:_____
- Area of survey conducted:_____
- Gender : Male ☐ Female ☐
- Educational Background:

  None ☐ Primary ☐ Secondary ☐ College / University ☐
- Annual Production (kg):_____
- Annual Sales (Birr): _____
- Price per kg: _____

1. Where do you bring the produce?_____
2. Time of transportation: Early Morning ☐ Day Time ☐ Night ☐
3. What means of transport is used for transporting the produce?_____
4. What kind of packaging method is used during transport?

   Sack ☐ Wood box ☐ Metal ☐ Plastic crate ☐
5. Is there any loss of the produce before it is sold? YES. ☐ NO. ☐
6. If your answer for Question number "5" is 'YES', how much could be the loss (%)?_____
7. For what purpose do you use the loss at your shop?

   _____
8. To whom do you sale your produce directly?_____
9. For how many days do you store the produce before it is sold to your customers?

   Less than 1 day ☐

   1- 2 days ☐

   More than 2 days ☐
10. During storage at retailers level (observational):
    - Ventilation: Good ☐ Medium ☐ Poor ☐

- Shelter: Sufficient shelter ☐ Poor shelter ☐ No Shelter ☐
- Mechanical/physical damage, during loading/unloading and transporting
  Significant ☐ Not significant ☐
- Loss due to pests: Significant ☐ Not significant ☐

11. Communication/Information
    - Price Information obtain: Daily ☐ Weekly ☐ Monthly ☐
    - Source of Price Information: Farmers ☐ Collectors ☐ wholesalers ☐ Retailers ☐ TV/Radio ☐
    - Need to get information on quality traits (Rank 1- 5, where 1list and 5 highest)
      Freshness ☐ Size ☐ Grading ☐ Firmness ☐
      Packing ☐ Certification ☐ Free from pesticide/fertilizer ☐
12. Have you any problem/challenge within the supply chain?

_____

_____

_____

III. Questionnaires Concerning PHL of Cabbage at Wholesalers Level

- Surveying Date:_____
- Area of survey conducted:_____
- Gender : Male ☐ Female ☐
- Educational Background:

  None ☐ Primary ☐ Secondary ☐ College / University ☐
- Annual Production (kg):_____
- Annual Sales (Birr): _____
- Price per kg: _____

1. Where do you bring the produce?_____
2. What means of transport is used for transporting the produce from farm to the wholesale market?_____
3. Time of transportation: Early Morning ☐ Day Time ☐ Night ☐
4. What kind of packaging method is used during transport?

   Sack ☐ Wood box ☐ Metal ☐ Plastic Crate ☐
5. How much does it cost a kilo of cabbage?_____
6. Is there any loss of the produce before it is sold? YES. ☐ NO. ☐
7. If your answer for Question number "5" is 'YES', how much could be the loss (%)?_____
8. For what purpose do you use the loss? _____
9. For how many days do you store the produce before it is sold to your customers?

   Less than 1 day ☐

   1- 2 days ☐

   More than 2 days ☐
10. To whom do you sale your produce directly?

    Retailers ☐ 'Gulit' ☐ Consumers ☐
11. During storage at wholesale level (observational):

- Ventilation: Good ☐ Medium ☐ Poor ☐
- Shelter: Sufficient shelter ☐ Poor shelter ☐ No Shelter ☐
- Mechanical damage, during loading/unloading and
  Significant ☐ Not significant ☐
- Loss due to pests: Significant ☐ Not significant ☐

13. Communication/Information

- Price Information obtain: Daily ☐ Weekly ☐ Monthly ☐
- Source of Price Information: Other farmers ☐ Collectors ☐ wholesalers ☐ Retailers ☐ TV/Radio ☐
- Need to get information on quality traits (Rank 1- 5, where 1list and 5 highest)
  Freshness ☐ Size ☐ Grading ☐ Firmness ☐
  Packing ☐ Certification ☐ Free from pesticide/fertilizer ☐

14. Have you any problem/challenge within the supply chain?

_____

_____