STORAGE SYSTEM IN TOMATO SUPPLY CHAIN OF ERITREA

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Specialization Post Harvest Technology and Logistics

By

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LIST OF ABBREVIATIONS

FAO	Food and Agriculture organization
APO	Asian Productivity Organization
MOA	Ministry Of Agriculture
GOE	Government of Eritrea
MOTI	Ministry Of Trade and Industry
NARI	National Agricultural Research Institute
ZECC	Zero Energy Cool Chamber
CA	Controlled Atmosphere
EMPC	Eritrean Marin Products Company

ABSTRACT

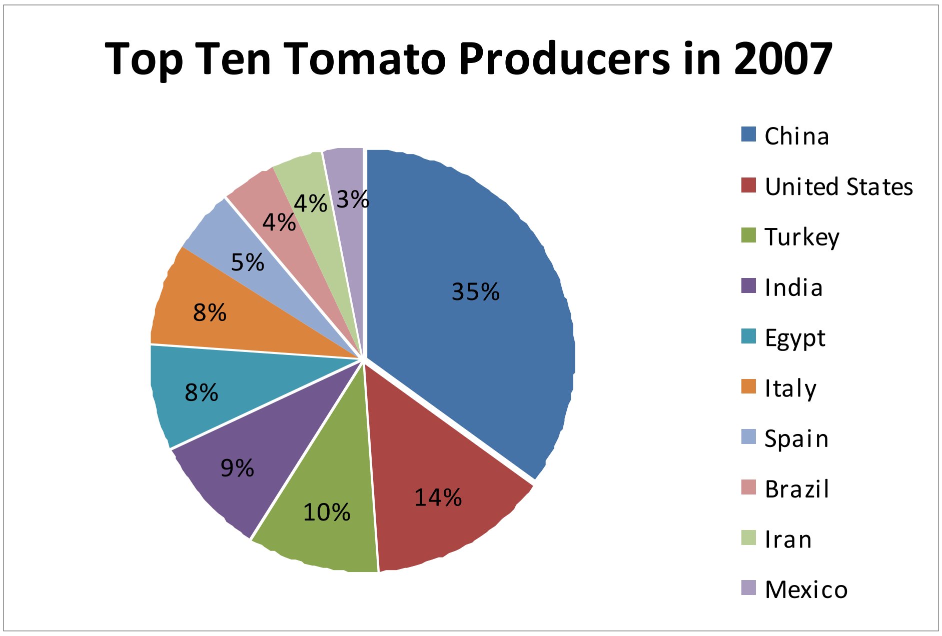
Tomato is one of the important fruits in Eritrea. Tomato is a perishable fruit that requires proper storage to reduce postharvest losses. However, Eritrea has no known proper storage facility to store tomato. This desk study is aimed at evaluating the contribution of storage of tomato in Eritrea based on interviews and secondary sources of information. The existing tomato supply chain was first identified and used as a baseline for comparing the cost-benefit analysis of the existing supply chain with a scenario where storage facilities exist. Local key informants from farmers and traders from four regions in Eritrea were approached to collect the information required through telephone interviews. Several types of storage are identified from the literature and their benefits and limitations are discussed in this study. The suitable storages were selected for a hypothetical scenario to help compare the cost benefit analysis.

From the findings of this study it was clear that there are many actors involved in the supply chain of tomato, making it a complex system where suppliers, farmers, wholesalers, transporters, processors, and government bodies are interacted. From the postharvest loss data collected from the interviews, it was clear that the large-, medium- and small-scale farmers, wholesalers and retailers were largely affected. Therefore, scenarios for storage facility implementation in the supply chain were considered, having in mind the applicability of the choice made in the local situation. Consequently the results of the comparative cost-benefit analysis showed that the profit margin for all the actors of the tomato supply chain considered in this study was profitable after the implementation of suitable storage facilities. In addition, the breakeven point showed that the scenario with storage and without storage is not largely different, with shorter breakeven point in some cases.

Therefore, from this desk study it can be concluded that the tomato supply in Eritrea has no storage facility at present and implementing storage facility in farmer and trader level could result in better profit and similar of lower breakeven point. This suggests that implementing storage facilities in Eritrea's tomato supply chain is a good alternative that need to be considered.

CHAPTER 1
INTRODUCTION

Tomato (*Lycopersicon esculentum*) has increased in popularity and has been rapidly expanded into large-scale cultivation during the last half-century. Tomato production has increased worldwide by 164% in the last 40 years and tomato world consumption has increased by 314% world (FAO, 2008). The consumption quantity in the world increased at the average speed of 3% yearly (Xinhua, 2007). The tomato world production is about 123.6 million tones of fresh fruit produced on 4.5 million ha. These data production is referred to 166 countries. The top 10 leading tomato producing countries are China, united state of America, Turkey, India, Egypt, Italy, Iran, Spain, Brazil, and Mexico (see figure 1). China is the major country for both area in cultivation (1,405,103 ha) and production (32.5 tones) with an average yield of 23 ton ha^{-1}. The two leading countries in fruit yield per hectare are the Netherlands (473 tones ha^{-1}) and UK (419 tones ha^{-1}), whose harvested area is 1,396 ha and 190 ha, respectively (FAO, 2008). The gap between harvested area and yield per hectare is due to the production system that changes from country to country according to environmental, technical and investment conditions.



Source: FAOSTAT

Figure 1 Top Ten Tomato Producers

Tomato is a perishable fruit that can be damaged by many postharvest factors, such as handling, transportation, packaging and storage problems. Harvested fruits and vegetables mostly have to be transported and processed before reaching customers for consumption (Yahia, 2009). However, not all the harvested produce are directly consumed, rather there is a series of storages between harvest and consumptions. Storages can be just after harvest, in between or after transportation, at the wholesalers, at retailers, or in the kitchen of the consumer (Boonyakiat, 2003). A proper storage is one of the factors that clearly reduce the loss of harvest in perishable fruits such as tomato.

Storage of fruit and vegetables help in scientific preservation of perishables stabilizes prices by regulating marketing period and supplies and it preserves the quality of the fruit till it reaches the end consumer (Rolle, 2006). In order to understand the contribution of storage facilities in a tomato supply chain, this desk study was supplemented by case study considering the tomato supply chain of Eritrea.

Eritrea is one of the developing nations located in North-eastern Africa, where agriculture is the main source of the economy. Varieties of agricultural produce are produced by commercial farmers and some subsistent farmers. Tomato is also one of the stable vegetables in Eritrea with the average production of 50 tones ha $^{-1}$ (Tesfalidet, 2008).Tomato is produced in Eritrea from small-scale to large scale farms, using different cultivars, in different socioeconomic settings and agro-ecologies (MOA, 2007). Tomato in Eritrea is mainly produced in four Zobas (regions). Out of the six regions, which are grouped based on agro-climatic and soil parameters (see figure2).

In the last few decades the tomato sub-sector of Eritrea has shown considerable progress in terms of area of production, yield, post-harvest technologies and marketing (GOE, 2008). Tomatoes are grown targeting fresh market and processing industry markets. The fresh tomatoes are largely produced and sold in diverse array of markets in the country ranging from farm-gate, local village and big city markets, and supermarkets (MOTI, 2006). In addition to the growth of tomato consumption in the world, there is a large domestic market demand for tomato in the country, since it is one of the main ingredients in the everyday traditional-food preparation. However, the ever increasing potential of tomato production and its marketing has not been fully exploited. The main challenge being that the tomato produced does not respond to the quality demand of the local consumers and that of the export market.

Present tomato quality standard in Eritrea is considered to be very low by international standards (MOTI, 2007). This low quality is the result of post harvest handling problems that also result in big quantitative losses of the product. This loss and the associated costs are the main reason for increased prices of tomato to the customers and very little gains, but not always, to the farmers.

Many research outcomes and country experiences show that well organized and managed post harvest handling and technologies can result in reduced crop losses (NARI, 2006). Therefore, the purpose of post-harvest handling is to mitigate the crop-loss in period between producer and consumer. One of the basic principles of the mitigation of the loss is by reducing the time interval between harvesting and consumption. Another principle can be having a technological investment in developing storage facilities for efficient supply chain. Most of the farmers in Eritrea have no access to storage facilities in their vicinity and the products they harvest are usually exposed to the influence of the weather until they are collected by the traders. The traders also do not have storage and preservation facilities and system for transporting the produce to the end user. Although customers are willing to pay more for higher quality tomato, the supply chain is not properly organized to allow modifications for better storage and preservation.

1.1 The Research Design

This section will explain the justification of the study, problem statement, the objective of the study, the research questions, the definition of concepts and the outline of the research.

1.1.1 Justification of the study

Farmers in Eritrea are limited in their know-how about storage of fruits and vegetables including tomato. The limited skilled manpower has drastically affected the financial gains from hard work in tomato production due to improper handling and storage systems. There is no identified (no study done yet for the chain analysis) tomato supply chain in Eritrea. This could be one of the limitations in solving the problems in the supply chain of tomato, because it is difficult to pin point where the problems exist without having a properly mapped supply chain. However, the problems of the tomato supply chain are beyond the limits of this study. Therefore, this study focuses on the storage problems in the supply chain that can potentially contribute to the post harvest losses. As there are no modern and advanced tomato storage systems in Eritrea it is considered as one of the biggest limitations in the supply chain. Storage facilities in developing countries, including Eritrea, are limited by luck of technological advancements and technical know-how. In addition, there is a difficulty in choosing suitable storage facilities, given the country's tomato supply chain, based on informed decision using cost-benefit analysis and a supply chain map.

This study will first investigate the different parts of the tomato supply chain and map the supply chain based on interviews with farmers in the country. These interviews will act as a case study in finding ways to recommend a suitable and functioning storage system for the country's farmers in different levels of production ranging from small scale farmers to large scale farmers, and traders i.e. wholesalers and retailers.

1.1.2 Problem statement

There is no known literature, mapping the supply chain of tomato in Eritrea. The supply chain in Eritrea is functioning with limited know-how and almost no documentation. Consequently, informed decision-making by pin pointing problems in supply chain is difficult. Furthermore, it becomes difficult to improve or solve the problems of the supply chain as it is difficult to know where the problem exists without the supply chain map and without identifying who the actors, affecting the supply chain are. One of the supply chain point, that is critical in Eritrea, is storage. Eritrea has a poorly developed tomato storage and preservation facilities that can be accessible to farmers and traders and there is not any known effort to develop such facilities soon. This has significant consequences in terms of larger postharvest losses and market price swings that may have impact on profitability of farmers.

1.1.3 Objective

The objective of the study is to evaluate tomato storage facility problems of Eritrea within the supply chain. It is, however, required to map the tomato supply chains in Eritrea in view of identifying the existing tomato supply chain problem with regards to storage.

1.1.4 Main Research questions

1. What is the contribution of storage in the tomato supply chain?

Sub questions

a. What are the appropriate storage facilities for tomato?
b. What factors are affecting storage life of tomato?

2. What are the appropriate tomato storage systems for Eritrean tomato supply chains?

Sub questions

a. What are the existing tomato supply chains in Eritrea?
b. What is the existing storage system of tomato supply chain in Eritrea?
c. What is the Cost-Benefit Analysis of tomato storage facility which can be feasible for Eritrean tomato supply chain?

1.2 The Definition of concepts

In order to get a better understanding of how the study is designed to address the research problem, the key concepts used in the research have to be clearly defined below.

- **Farmers**

In this study farmers are classified into large, medium and small scale, in term their area of farm***.***

- Large scale farmers are those who have more than 20 ha farm area.
- *Medium scale farmers* are those who have ranging between 5 and 20 ha
- *Small scale farmers* are farmers who have less than 5 ha.

- **Supply chain**

A supply chain encompasses all the facilities, functions and activities involved in producing and delivering a product or service from various suppliers to the final customers (Russell and Taylor, 1998 cited in Duren and Sparling, 1998). Or it can be also referred to a sequence of (upstream) sourcing and (downstream) marketing functions of individual enterprises.

- **Cost-benefit analysis**

A cost benefit analysis is done to determine how well, or how poorly, a planned action will turn out. Although a cost benefit analysis can be used for almost anything, it is most commonly done on financial questions. A cost benefit analysis finds, quantifies, and adds all benefits. Also it identifies, quantifies, and subtracts all the negatives, the costs. The difference between the two indicates whether the planned action is advisable.
In this study, cost benefit analysis of the tomato supply chain of Eritrea was carried out. In addition a cost benefit analysis of the supply chain was compared with hypothetical supply chain that has improved storage facility to determine the feasibility of implementing improved storage facility in the existing supply chain.

- **Feasibility**

Feasibility can be one or a combination of technical, economical, environmental or operational aspects. However in this study the feasibility of the storage is only looking at the economic aspect.

- **Breakeven point**

Breakeven point is a point where there is complete payment of the investment and any revenue generated after that is a profit. In this study breakeven point analysis was performed in order to easily compare between the existing and the hypothetical storage facility scenarios of the supply chain.

1.3 Report outline

This study is organized into six main chapters. Chapter one introduced the research topic, study area and the research design which briefly describe the research problem, research objective and two main research questions with their respective sub questions. The chapter concludes by clarifying key concepts used in the research.

In Chapter two the research methodology is discussed in detail about the data collection methods and the tools for data analysis. Chapter three is showing the literature findings of proper storage facilities for tomato and some factors that affect the storage life of tomatoes. Chapter four the tomato supply chain of Eritrea is mapped from findings of the case study. In chapter five the cost benefit analysis of the findings from the case as well as from the literature will be analyzed. Chapter six discusses the results of the case study. The thesis report ends with chapter seven which formulates the conclusion and recommendations out of the study.

CHAPTER 2
METHODOLOGY

This section presents the research approach used in the study and the different data collection and analysis methods employed to generate answers to the research questions. The research was carried out by means of a desk study supplemented with a case study involving local Key Informants interviewed through telephone communication. This study has three components:

- Literatures study about storage facilities and tomato factors.
- The supply chain was mapped and the different actors were identified and placed according to their influences using information provided from the key informants.
- A Cost-benefit analysis was carried out using the information found from secondary sources and supplemental information was collected from the key informants.

The local key informants are farmers, wholesalers, and retailers. The data collection and analytical approaches are presented below.

2.1. Data collection

2.1.1 Secondary data collection

The secondary data sources such as documents of FAO, MOA and MOTI (proposals and reports), scientific books, PhD thesis, and relevant published and non published reports were reviewed to generate secondary data on the tomato sub sector of Eritrea to fill the data gap that was missing for the study.

Moreover relevant information and literatures were collected from reliable internet sites on the storage systems of different countries, and on tomato quality.

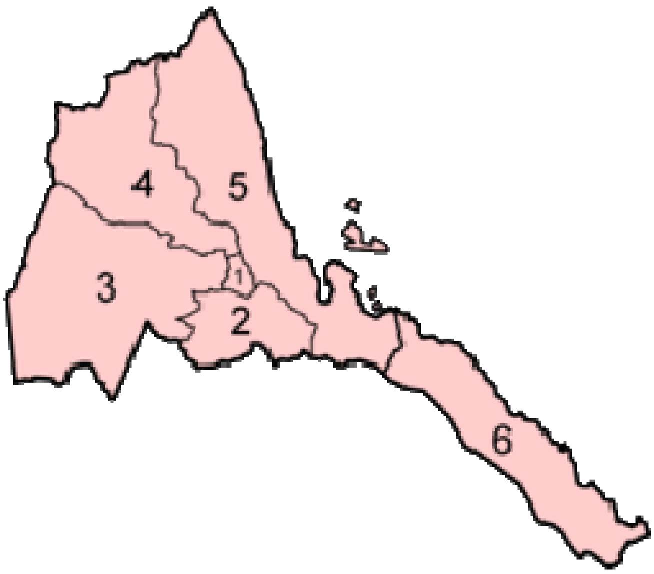
2.1.2 Primary data collection

In order to validate the result of the desk study of tomato supply chain in Eritrea, a case study research was designed. This case study was carried out by interviewing 29 key actors (farmers and traders) through telephone, in order to identify the sub sector tomato supply chain in Eritrea. The study also provided information about the existing storage system of tomato at each actor level. Interview questions were based on the questionnaire designed for this case study (Appendix 1). The interview was carried out with the following sampled interviewee***:***

1. A total of nine small scale farmers three each from three regions i.e. Zoba Maekel, Zoba Debub and Zoba Anseba (see figure 2).
2. A total of nine medium scale farmers, three each from three regions namely Zoba Anseba, Zoba Gash Barka, and Zoba Debub.
3. A total of three large scale farmers each from three different regions namely, Zoba Anseba, Zoba Gash Barka, and Zoba Debub. According to the report of the ministry of agriculture (2007), these large scale farmers are not completely privately owned, some part of the share is owned by the government. These

farms are five in number. Majority of the farmers are located in Zoba Gash Barka (i.e. three farmers). There is one large vegetable farm in Zoba Anseba and one in Zoba Debub. However, with the assumption that farmers in Zoba Gash Barka region have the same activities and have the same distance to the market, only one farmer were interviewed from this region. Although some of the medium farmers are also located in the same area as with large scale farmers, they have high diversity in their investment and large differences in know-how so that nine sampled medium farmers were interviewed.

4. Four wholesalers and four retailers from Zoba Maekel (Central region) were interviewed to get information about the current storage practices of tomato and their marketing systems. This region was particularly selected because of the high tomato consumption (MOTI, 2007). Two big wholesalers and two small wholesalers were interviewed. The big wholesalers are those who have as share with the government and the small wholesalers are those who are privately owned. The majority, that is 70% of the total tomato produce (according to MOTI,2007) is marketed in Supermarkets and Open markets. Therefore, the interviews of the retailers only held with the retailers of these groups.



Sources: http://en.wikipedia.org/wiki/Regions_of_Eritrea
FIGURE 2 REGIONS OF ERITREA

(1) The Central High Land Zone (Zoba maekel)
(2) The South Western Lowland Zone (Zoba Debub);
(3) The North-western Lowland zone (Zoba Gash Barka)
(4) The Western Escarpment Zone (Zoba Anseba)
(5) The Green Belt of the Eastern Escarpment of the Highland Zone (Zoba Northern Red sea)
(6). The Coastal Plains Zone (Zoba southern Red sea)

Moreover in this study information about missing prices of some items and price of cold storage investments costs are consulted form the MOTI and EMPC (Eritrean Marine Products Company) respectively.

2.2 Data analysis

The cost of production of tomato supply chain of large , small, and medium scale farmers were analyzed using Microsoft Excel. The Cost-Benefit Analysis was used to find out profitable tomato storage facilities which are practical for Eritrean tomato supply chain based on the desk study findings. Supply chain analysis was employed to analyze the storage systems of tomato chain and insight into the actors' roles and relations. Furthermore, the study also evaluated risk analysis of the storage technologies.

2.3 Limitations of the study

Most of the actors in the supply chain do not have the exact value of their costs. In such cases, the research tried to cross check the prices of some items from referring some people from MOTI, department of trade and information (TI).

CHAPTER 3
STORAGE OF FRESH FRUITS AND VEGETABLES

3.1 Introduction

Storage has been developed to ensure the supply of an agriculture product to consumers with minimized quality degradation. Orderly marketing of perishable commodities often requires some storage to balance day-to-day fluctuation between product harvest and sales or for long-term storage to extend market period. (Tripath and Bhat 2000). Fresh fruit and vegetables, including tomato, are also perishable in nature. Fresh fruits and vegetables as living tissues are subject to continual changes after harvest. Such changes cannot be stopped but can be controlled within certain limits by using various postharvest procedures (Verlinden and Nicolai, 2000). Procedures of storage may include (a) lowering the temperature to slow respiration and senescence, (b) maintaining optimal relative humidity to reduce water loss without accelerating decay (c) adding chemical preservatives to halt physiological and microbial losses, and (d) maintain an optimal gaseous environment to slow respiration and senescence. Longer shelf life can also be obtained by selecting cultivars that are more able to withstand the handling systems and by harvesting the crop at optimal maturity (Salunkhe and Kadam 1999). The harvesting of fruit at an appropriate stage is important from post harvest shelf life and quality point of view (FAO and APO 2006).

Lee and Kader (2000) also clarify that Storage of a commodity serves as a means to extend the season, to delay marketing until prices rise, to provide a reserve for more uniform retail distribution. They also mentioned that the shelf life of a fruit or vegetable during storage is dependent on its initial quality, its storage stability, the external conditions and the handling methods. Shelf life can be extended by maintaining a commodity at its optimal temperature, relative humidity (RH) and environmental conditions, as well as by the use of chemical preservatives.

3.1.1 Goals of storage

According to Tripath and Bhat (2000) there are three main goals of storing fresh fruit and vegetables:

- To slow biological activity of the produce at low temperature with controlled atmospheric composition that will not cause chilling and freezing injury to the produce
- To reduce product drying by reducing the difference between product and air temperature and maintaining high humidity in the storage room
- To slow the growth of microorganisms.

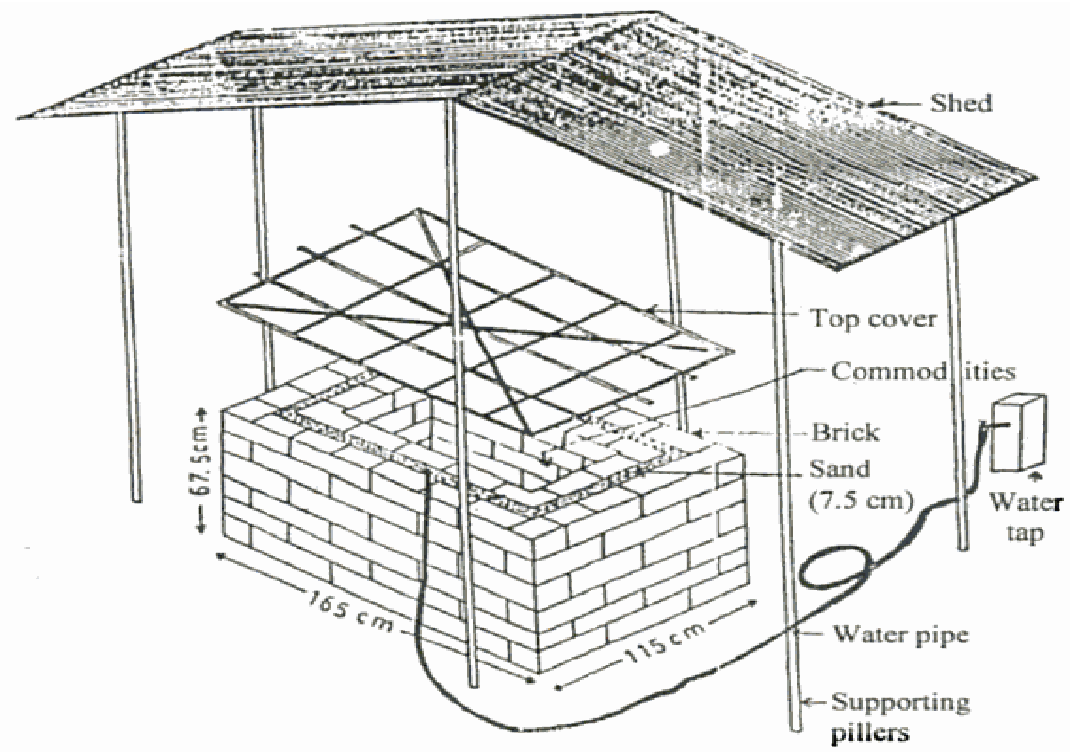
3.2 Appropriate Storage facilities for tomato

The need for storage is a critical step in the total supply chain of tomato. There are different types of storage developed in the world. Some of the storage technologies that are suitable for tomato storage are briefly discussed in this section.

3.2.1. Low cost storage technology

Low temperature storage by refrigeration is the most effective measure to minimize the perishability problem of fresh produce but the high initial and operational costs preclude its widespread use. Alternative low-cost storage methods, such as the use of simple evaporative cooler (EC), is necessary particularly for small farmers and entrepreneurs who dominate the vegetable industry in developing countries (Acedo, 1997). Evaporative cooling system maintains a cool and humid environment as the heat from the storage chamber is dissipated with the evaporation of water. The decrease in temperature is usually small but the increase in humidity could be substantial, so that deterioration due to moisture loss is retarded. A number of simple and low-cost EC have been effective in improving shelf life of vegetables (Vanndy, Buntong, Chanthasombath, Sanatem, Acedo, and Weinberger 2008).

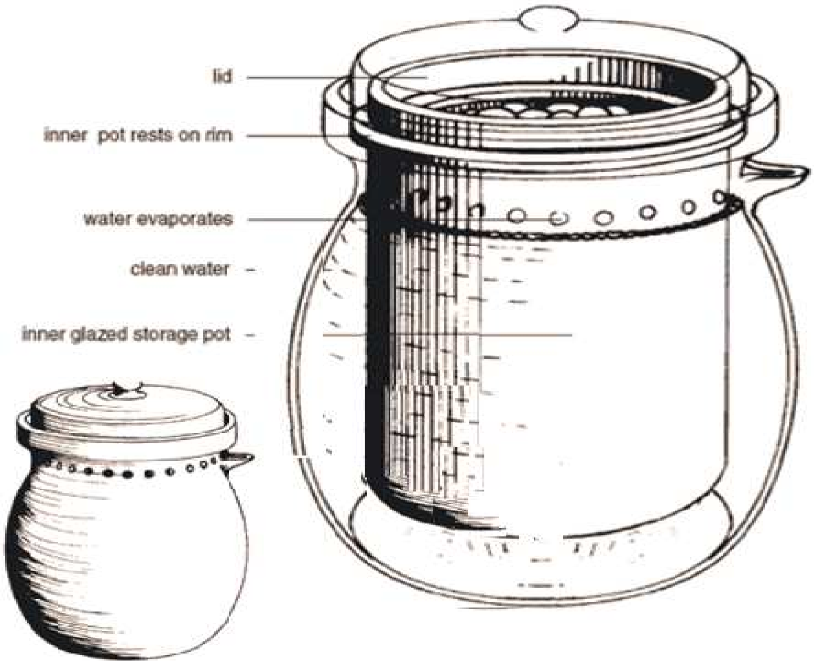
Zero energy cool chamber (ZECC): is an on-farm rural oriented storage structure which operates on the principle of evaporative cooling (see figure 3). It does not require any electricity or power to operate. It is consists of a single layer of bricks as floor, the side wall with double layers of bricks have 7.5 cm space between the two layers which is filled with sand and the top is covered with bamboo and/or gunny cloth structure. The chamber wall should be kept by continuous sprinkling of water for evaporative cooling to reduce the temperature by 17 – 18 ^{0}C. It is used mainly for storing of fruits, vegetables and as well as flowers. This system is used for small scale production and the materials required to make this chamber are cheap and easily available (Roy and Pal 1999).



SOURCES: http://www.fao.org/wairdocs/x5403e/x5403e33.gif

FIGURE 3 ZERO ENERGY COOL CHAMBER

Shital pot low cost storage: Low cost mud refrigerator named, Shital pot was found effective in prolonging the shelf life of fresh fruits and vegetables (Indian food- General n.d.). Shital pot consisted of i) an outer pot (with water), ii) an inner pot resting inside the outer post over a stand and iii) a detachable perforated mud lid or jute cloth or bamboo frame placed on top of the outer pot (see figure 4). The evaporative cooling occurs between the outer and inner pots which keeps the products placed inside cool.



SOURCES:http://tilz.tearfund.org/NR/rdonlyres/C0A323F6-287D-4D1E-8511-A868249B54F7/0/FS2116Cooler1.gif

FIGURE 4 SHITAL POT LOW COST STORAGE

Advantages of low cost storage	Disadvantages of low cost storages
• Not technically difficult to build. • No running costs once constructed. • Different vegetables can be stored together in the ZECC	• Temperature control is minimal • Inspection during storage is not really practical as the crates are placed one over the other in ZECC and as bulk in the Shital pot storage systems.

3.3.2 High cost storage technology

Refrigerated storage (Cold storage): Cold storage is a technology used to preserve the perishable commodities of food items for a longer period of time under low temperature. The principle of refrigeration works by moving heat from the object at higher temperature to that at lower temperature. Refrigeration creates a cold surface that absorbs heat transferred to it by conduction, convection or radiation. It helps to retain the original colour, flavour and taste of the food items. However, each commodity or item has certain life and they cannot be stored even in a cold storage for indefinite period. Storage beyond certain period may not be economical as well, since the cost of cold storage increases with the time the food items are stored. Hence, cold storages are used for high value items or when prices crash down due to bumper crop or for such items which are grown during the season but there is a demand all year round.

Hypobaric storage (low pressure storage): Fruits can be stored under less than atmospheric pressures (hypobaric storage). In this storage system humidified air was passed through the chambers to remove volatiles given off by the fruits. Because of the drying effect of partial vacuum there is a reduction in the level of ethylene in the fruit and O2 in the chamber. The mechanism of Hypobaric storage functions as a result of reduced O2 supply that slows down the respiration and production of ethylene, flushing of ethylene removed from the fruit out of the storage and removal of other volatiles produced by the fruits such as CO2, acetaldehyde, etc. When the atmospheric pressure is reduced from the normal atmospheric pressure, the O2 concentration is lowered and the level of ethylene is also reduced limiting the stimulation of ripening (Tripath and Bhat, 2000).

Controlled Atmospheric Storage (CA) storage:Controlled atmosphere storage works on the principle of removing oxygen from the store atmosphere and increasing the levels of carbon dioxide so that crop respiration is slowed down thereby prolonging the storage life of the crop. This effect is usually enhanced by cool conditions so the stores are also refrigerated. Levels of ethylene, which control ripening, can also be removed from the store atmosphere to lengthen storage life. It can take some considerable time for the correct levels of gases to be reached so in practice nitrogen is commonly injected into the stores to evacuate oxygen quickly.

The levels of gases in the store have to be carefully regulated or physiological damage, tainting of flavour and loss of texture are but a few of the symptoms that can occur if things go wrong. Crop species, variety, mineral status of the crop and conditions during crop growth are all known to affect the required optimum levels of oxygen and carbon dioxide. For these reasons it is not possible to store different crop species together, nor is it advisable to store different varieties together.

Controlled atmosphere storage is expensive. The store needs to be airtight and equipment is required to monitor the levels of gases as well as add or ‘scrub’ these gases. For this reason it is only worthwhile using controlled atmosphere storage if the crop can be sold for a premium after storage, or where refrigeration alone is not enough to guarantee long term quality. (Bevan, Firth and Neicho, 1997)

Advantages	Disadvantage
• Retardation of senescence and associated biochemical and physiological changes (slowing down respiration and ethylene production) • Reduction of fruit sensitivity to ethylene action at lower O_2 levels and higher CO2 levels .	• Initiation of certain physiological disorders • Irregular ripening of tomato • Development of off-flavours and off-odours at very low O_2 concentration • Crop stored must be high value to justify high capital and running costs, buildings usually have to be gas sealed although nitrogen flushing can be used if not. Store must be flushed out before personnel can enter unless own oxygen supply used.

Modified Atmosphere (MA) storage implies a lower degree of control of gas concentration in atmosphere surrounding the commodity stored. Historically, atmospheres surrounding the produce have been altered in CA storage facilities where the level of gases are continually monitored and adjusted to maintain the optimal concentrations. The MA and CA differ only in the degree of control; CA is more exact (Hassan and Maroc 2001).

3.4 Factors affecting storage life of tomato

Tomato quality components include appearance (color, size, shape, freedom from defects and decay), firmness, flavor, and nutritional value. These components are related to their composition at harvest and compositional changes during postharvest handling.

The physiology of storage

Harvested tomatoes are still alive and biologically active. Respiration is one of the most important metabolic processes concerned with storage. Carbohydrates are broken down by oxygen (with the help of enzymes) to produce carbon dioxide, water and heat (Bevan, Firth and Neicho, 1997). For successful storage, this process needs to be slowed down as much as possible without actually killing the tomato friut. In this way water loss, weight loss, and excessive heat production can be minimized Irtwange (2006).

Reducing the temperature of the produce tends to slow down all metabolic processes including respiration, and therefore prolongs the storage life of the tomatoes. Excessive cooling however, (i.e. temperature below 10-12 ^{0}C) will cause chilling, frosting, cell death and finally decay(Safdar, Morimoto and Hatou , 2008).

Ethylene is another gas important in storage, affecting ripening, maturation and onset of cell death. It is produced by the tomato itself, and some fungi and bacteria which cause storage rots.

Water loss: High temperature and injuries to produce can greatly increase the loss of water Maximum storage life can be achieved by storing undamaged produce at the optimum temperature tolerable by tomato.

Mechanical damage: Decay of fresh tomato during storage is mostly caused by the infection of mechanical injuries. Damage caused during harvesting and subsequent handling increases the rate of deterioration of produce and renders it liable to attacks by decay organisms.

Decay in storage: tomato fruits, like many fruits and vegetables, can be attacked by decay organisms which penetrate through natural openings or even through the intact skin. These infections may be established during the growth of the plant in the field but lie dormant until after harvest, often becoming visible only during storage or ripening.

3.5 Tomato storage

Tomato fruits are often harvested at a mature green stage to minimize damage and to allow ripening before or during presentation in retail outlets. However, tomato is a typical climacteric fruit that exhibits a dramatic increase in ethylene production and respiration rate associated with a short post-harvest life at ambient temperature (Yu, Baogang and Lite 2008).
Access to suitable storage can help in the marketing of tomatoes because deterioration and waste can be reduced considerably. Supplies from seasonal production can be marketed over longer periods, reducing the short term excesses and facilitating a more even flow of the fruit to the consumer. Although fresh tomatoes do not have long storage life, the application of existing technical knowledge can prolong storage life and make an appreciable contribution to overall postharvest needs.
Refrigeration (Cold storage) is usually used to store tomato fruit as it has a beneficial effect on extending storage life. Nevertheless, tomato fruit are sensitive to chilling injury at temperatures below 12℃. According to Quisqualis (2008), Cold st orage increased the shelf life of tomato by reducing the rate of biochemical changes and also slows down the growth of contaminating micro-organisms.

The factors that control the shelf life of fresh tomato fruits in cold storage include:

- The condition of the fruit at harvest (e.g. the presence of damage or microbial contamination, and the degree of maturity).
- The temperature during harvest.
- The relative humidity of the storage atmosphere, which also influences weight losses due to drying out.
- The composition of the storage atmosphere

Proper storage conditions, temperature and humidity, are needed to lengthen storage life and maintain quality of harvested tomato fruits. Fresh fruits need low temperature and high relative humidity to reduce the respiration and slow down the metabolic process in cold storage. Table 1 indicates optimal temperature and moisture condition of mature green and ripe tomatoes in cold storage.

Table 1 Optimal temperature and moisture condition of mature green and ripe tomato in cold storage

Product	Optimal Storage Temperature (0C)	Freezing Point	Optimal humidity (%)	Approximate Storage Life	Comments
Tomatoes, mature green	13-21	-0.6	90-95	1-3 weeks	Riping can be delayed by storing at 13-16 oC
Tomatoes, ripe	13-21	-0.5	90-95	4-7 days	

SOURCES: www.engineeringtoolbox.com/fruits-vegetables-storage-conditions-d_710.html

According to Bangerth (1999) tomatoes can be stored in hypobaric storage at 75 Torr for almost 7 weeks, without any appreciable losses and without interfering with post- storage ripening as compare to maximum 3 to 4 weeks of the conventional CA storage.

According to Verma and Joshi (2000) the hypobaric storage method also offers some other advantages compared to the conventional CA storage. It is possible to open and enter frequently without influencing the fruit result. This is because optimal storage conditions are obtained again a short time after closing. The necessary operating controls are simpler than with CA storage and are less restricts to the pressure control.

The major advantage of cool chamber storage was the maintenance of fruit firmness by lowering the physiological loss in weight and other metabolic processes. According to George and Pathak (2007) a study carried out on the performance evaluation of cool chambers for short term storage of tomatoes results revealed that tomato could be stored successfully up to 20 days in Zero Energy Cool Chamber (ZECC) with minimum physiological loss in weight compared with maximum 11 days at ambient condition. Quality attributes like total soluble solids, total and reducing sugar content of tomato increased gradually up to certain period of storage and thereafter decreased. However, an increase in carotenoids throughout the storage period was observed. The rate of change in quality parameters was more pronounced under ambient storage.

CHAPTER 4
TOMATO SUPPLY CHAIN MAP OF ERITREA

This chapter describes the findings of the interviews with the farmers, wholesalers and retailers. Additional information and also some missing information were found from the literature and consulting people form MOTI. And the result shows that there exists non-identified supply chain of tomato in Eritrea. The supply chain shows how the current tomato chain in Eritrea is organized, how different stakeholders influence and support the chain, and how the farmers, wholesalers and retailers store their tomato. According to this information the supply chain has been mapped (Figure 5).

4.1 Input supplier

4.1.1 Planting material

Farmers in Eritrea have different sources of tomato seed supplied from different suppliers. Most of the large scale farmers produce their tomato seed form their own nursery farm, although they sometimes purchase seeds from agro-seed suppliers. On the other hand, the medium and small scale farmers mostly purchase seeds from the Ministry of Agriculture at cheaper prices and grow it in their land or backyard, which may be transplanted later in bigger land.

4.1.2 Fertilizer and pesticides

For medium and small scale farmers the government subsidizes the required fertilizer and pesticides through Ministry of Agriculture. In addition to subsidizing the fertilizers and pesticides to these farmers, Ministry of Agriculture also provides loans with no interest to finance the inputs of the farming. The amount of the loan may be different depending on the area of their cultivated land. However, excess fertilizer or pesticide can only be purchased from the agro input suppliers in the market where the farmers are required to pay in cash. In case of the large scale farmers, all inputs are bought form the agro suppliers with no subsidization from the government.

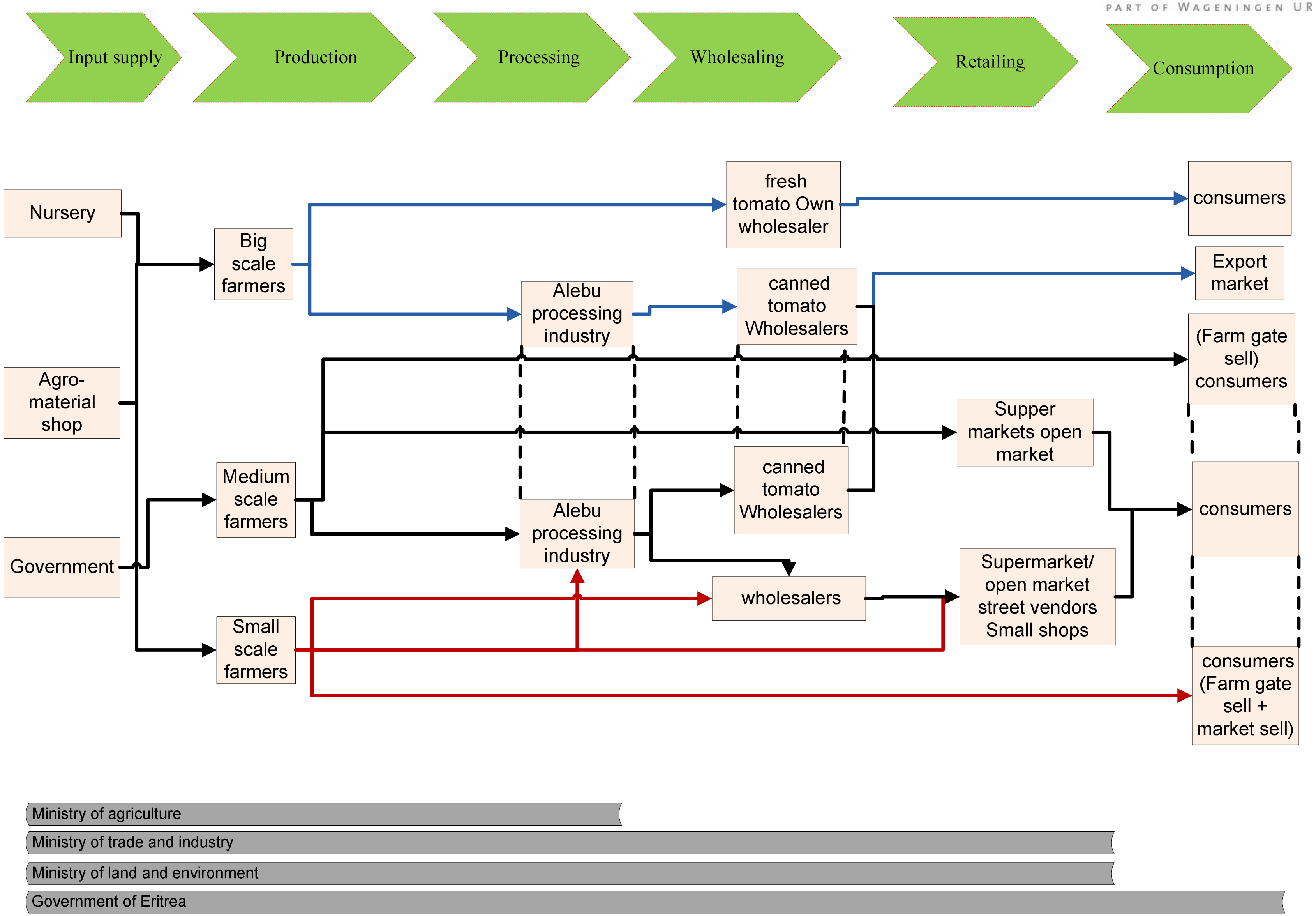


Figure 5 Tomato sub sector in Eritrea

4.2 Farmers

4.2.1 Large scale farmers

Large scale farmers have an estimated average area of 35 ha. All of these large scale farmers are not completely privately owned; rather the government also owns some shares in order to be able to stabilize the market of the most common crops (crops which are demanded on people's daily life such as tomato and onion). In turn, these large scale farmers get labour freely from the military and also mechanized farming equipments from the MOA. Land lease is also freely provided during such business arrangements, which otherwise be extremely expensive for such farmers. From the data of the Ministry of Trade and Industry (MOTI, 2007), there are only seven large commercial fruit and vegetable farmers in the country, with most located in Zoba Gash Barka. This region is well suited for farming due to the availability of many temporal rivers and the large uninhabited arid land available for expansion (MOA, 2007). Other regions also produce fruits and vegetables, but in small scale due to the suitability of the climate for other crops and high density population, which competes for land use rights.

Large scale farmers usually have warehouses, where their produce is stored or kept. As these farmers have multiple crops in their farm their warehouses are not constructed to the requirement of each produce, rather all of their produce is kept in one warehouse regardless of what is harvested. For example, tomato harvests are stored together with onions, potatoes and chilies and no special storage requirements of each produce. Even though there is only few losses at the farmer level (because tomato is harvested before it is fully ripe), there is large losses during storage due to some damages that results in poor tomato quality when it reaches at the consumer level.

4.2.2 Medium scale farmers

Medium scale farmers have an estimated average area of 16 ha. Most of the medium scale farmers, as in the large scale farmers, are located in the three regions i.e, zoba Anseba, zoba Debub and zoba Gash Barka.

The result of the interviews showed that most of the medium scale farmers do not have proper onsite storage warehouse. For example out of the nine interviewees only three of them have proper warehouse (In this study proper warehouse refers to the house which are build by brick or stone material with ventilation in it, and also low attack by rodents and birds). The others are only keeping the crate full of tomato under shade house. Therefore most of the farmers usually try to ensure a market of their harvest. However, the market prices usually dictate their sale and due to the lack of storage they usually are forced to sell their tomato produce at cheaper prices. Farm gate sells are usually carried out at cheaper prices to the community around the farming area. However due to low advertisements and transport coordination for the inhabitants in the farm area, the sales are usually limited. As a last resort for not having storage, the medium scale farmers usually sell their harvests to processing factory for canning. This canning factory are government owned and are situated in a remote area near to the large scale farm in Gash Barka region that small scale farmers especially in Zoba Anseba and Zoba Debub, cannot be able to transport their produce to sell to the processing company. The transport cost is very expensive to the farmers. Some of the medium scale farmers located in Gash Barka and Zoba Anseba regions have a better benefit in their sell to the processing factory, although their profit margin is not big as compared to fresh tomato sell.

4.2.3 Small scale farmers

According to the report of GOE (2008) the larger number farmers operate as small scale farmers. These farmers have an average area of 2 ha each. Although their production is not large for each of the individual farmers, thereby their total postharvest losses are significantly high Mohammedbirha (2008).

Although the Small scale farmers do not have a proper storage facility, some of them usually use traditional cooling system that functions by covering the tomato placed in a box with a wet sac (or cloth) so that the tomato will be maintained colder than the outside temperature. The zoba Anseba farmers are all (from the interviewees) use this system; this is because of the climate (hot) condition of that region and relatively far places from the market area. However, the other region farmers do not use this system.
These farmers, as in the medium scale farmers, are selling their tomato to consumer directly, to wholesalers and retailers by the expense of their transportation. Those farmers of Anseba region have also an opportunity to sell to the processing company.

4.3 Transporters

According to MOA (2007) the higher number of consumption is confined in Zoba Maekel, particularly in Asmara, and almost all the production from all over the country is sold in this region. The large scale farmers have their own trucks to transport the tomato from the farm to their wholesale shops and also to the processing company. However, most of the small scale farmers form Zoba Maekel transported the tomato by canters to the market area. As an alternative, public transport is also used for transporting the tomato by small scale farmers in Zoba Maekel. The tomatoes are usually packed in wooden boxes and packed on top of the buses for transporting it to the cities. Similarly, the medium farmers transport the tomato using canters and trucks, and sometimes public transports. However, all these systems of transportation do not have any preservation facilities, and during the transportation process of loading and unloading in the wooden boxes, a significant quantity of the produce is damaged. Such handling reduces quality of the tomato and the shelf life is deteriorated when it reaches to the market place in the capital city, Asmara.

4.4 Processers

According to the MOTI (2007), Alebu-Banatom Factory is a big processing factory which is owned by the Government. This factory is processing tomato and banana in subsequent months. This processing company has a capacity to process 500 tons of tomatoes in over three months on a daily basis (Kahsai, 2009). However, all the production is for export market. And it is placed in Zoba Gash Barka where most of the large-scale farmers are located.

4.5 Wholesalers

According to MOTI (2007), there are two kinds of the wholesalers. Those who are selling directly only to individual consumers and those who are selling to retailers, restaurants and institutions (university cafeteria, and hospitals). The wholesalers who only sell to individual consumers are owned by the large scale farmers (commonly called big wholesaler) and are located in the capital city. On the other hand the wholesalers (commonly called small wholesalers) selling to retailers, restaurants and institutions are privately owned and also are located in some other small cities apart from Asmara. In both cases there is not proper storage facility in their shops. According to the wholesalers 15 -30 % (depending on season) of tomato produce was accounted as postharvest losses in the wholesale market due to lack of storage.

4.6 Retailers

According to MOTI (2007) there are four officially known types of retailers in the country such as supermarkets, small shops, open markets and street vendors. Similar classification also applies to retailers in Zoba Maekel.

The retailers usually keep the tomato for longer period for sell to customers in small quantities. During this period, some of the supermarkets and small shops use refrigerators for cooling the tomato and increasing the shelf life. However, they cannot be able to maintain more that 10 kilograms of tomato at a time in their refrigerator. The Open market and street vendors, on the other hand, have no way of storing the tomato and the quality and hygiene of tomato in such retailers is very poor.

These retailers buy the tomato from wholesalers and supply to consumers. Due to the regulatory policy of the government in price control these retailers are not allowed to buy the tomato directly from the large scale farmers. As these large-scale farmers are mainly, at least in part, owned by the government these regulations take effect. However, in they have the liberation to buy tomato from the medium- and small-scale farmers.

The open market is a large open sided hall where only fruits and vegetables are sold (see figure 6). From information obtained from the interview with one of the open market retailer, all of the retailers in that open market have no storage facility. They do not even have enough space where they can keep their tomato properly. They leave the tomato with other fruit and vegetable during the night time in the same position by only covering them with a plastic and cloth covering, usually known as '' Tenda``.

From the interviews held with two supermarkets it was possible to identify the source of the tomato supply and their storage techniques. The information collected indicated that tomatoes were supplied from different suppliers including wholesalers and farmers. It was found out that these retailers purchase large quantities from farmers and small quantities from wholesalers, due to the reason that the purchasing price direct from farmers is cheaper, allowing them to take a risk in buying large quantities of the perishable tomato. In the case of large purchases, the tomato retailers use refrigeration to keep large stock in the shop. The retailers purchase small quantities from wholesalers due to larger prices and lower quality of tomato that took longer time to reach the market after harvest. However, the storing of tomato stock in the refrigerator was usually done without any packaging.

SOURCE: http://i.pbase.com/u39/tiggy67/upload/25360967.VegMarketAsmara.crop.jpg

Figure 6 Open market in Eritrea

4.7 Stakeholders

4.7.1 Ministry of agriculture (MOA)

The ministry of agriculture is supports the tomato farmers in many aspects, like subsidizing the seeds, fertilizers and pesticides. And the ministry also carries out a research by its branch office (National Agricultural Research Institute) which is aimed for the improvement of tomato subsector.

4.7.2 Ministry of trade and industry (MOTI)

Ministry of trade and industry is responsible for implementation of trade policies of taxation and ensuring industrialization of the Eritrean economy. And this ministry supports the tomato farmers by constructing one big processing factory in the country that can purchase the produce when market supply exceeds the demand.

4.7.3 Ministry of land and environment (MLE)

This Ministry is responsible for allocation of farming land to the farmers. The Ministry helps the farmers by allocating suitable farming land to able-farmers and motivating them for expansion based their performance.

4.7.4 Government of Eritrea (GOE)

The government of Eritrea has a policy for the development of Agricultural productions. Therefore for any item, used for development of the farmers as well as the country, the tax is free. This opportunity is more encouraging the agriculture sectors including horticulture sector.

CHAPTER 5
VALUE ADDITION IN THE TOMATO SUPPLY CHAIN OF ERITREA

5.1 Cost-Benefit analysis at farmers level

The cost-benefit of production for tomato in Eritrea in different farming levels are shown in Table 2 (refer Appendix2,3 and 4 for detailed row data). The costs of production increased with increase in the scale of farming, mainly attributed with large quantities of input factors such as labour, seed, fertilizer and pesticide, but to a large extent also with increase in postharvest losses (refer to appendix 6). The implementing storage will have an overall financial benefit for the farmers considered. (i.e. the large, medium and small farmers). All the currency in this study is in Nakfa (20 Nakfa is equivalent to 1 Euro.

It is evident from Table 2 that the fixed cost has increase due to the investment of the storage facility for all farmers in the hypothetical scenario. However, the variable cost and revenue generated from reducing the cost of losses and sell, thereof, of the tomato has been large enough to increase the profit in all the farmer groups under the hypothetical scenario of availability of storage facility. Therefore, when compared to a hypothetical scenario where proper storages were available in the supply chain, the cost-benefit analysis showed a large reduction in post harvest losses (the assumed 80% percentage reduction from the total postharvest losses) that reduced the cost and increased revenue. Although the storage facilities used are different with each scale of farm, all the hypothetical storage facilities has resulted in higher revenue and higher profit with slightly lower breakeven point (Figure 7).there was a slightly lower breakeven points for large (0.4to 0.3 year) and medium scale (0.3 to 0.28)farmers. However the breakeven analysis showed that the investment paid back from the storage facility investment by small scale farms are almost equal to that of the farm without storage facility. However, in the scenarios of the cost benefit analysis the cost of the cold storage was collected from the EMPC (Eritrean Marine products Company). The generalized (no technical information was available) estimated cost was approximately 40,000 Nakfa.

Table 2 Summary of cost benefit analysis of farmers under current operation of supply chain without proper storage and a hypothetical scenario with proper storage facility

Costs (Nakfa)	Large-scale Farms		Medium-scale Farm		Small-scale Farms	
	without storage	with storage	without storage	with storage	without storage	with storage
[A] Fixed cost	7,438,000	8,538,000	2,586,395	2,866,395	44,633	59,633
[B] Variable Cost	7,570,363	3,867,463	1,783,461	1,043,891	44,700	29,380
Total Cost	15,008,363	12,405,463	4,369,856	3,910,286	89,333	89,013
[C]Total Revenue	27,004,500	30,762,900	10,502,218	11,255,288	176,461	192,981
[D] Profit/Loss [C-B]	19,434,138	26,895,438	8,718,757	10,211,397	131,761	163,601
Breakeven Point (yr) [A/D]	0.4	0.3	03	0.28	0.3	0.3

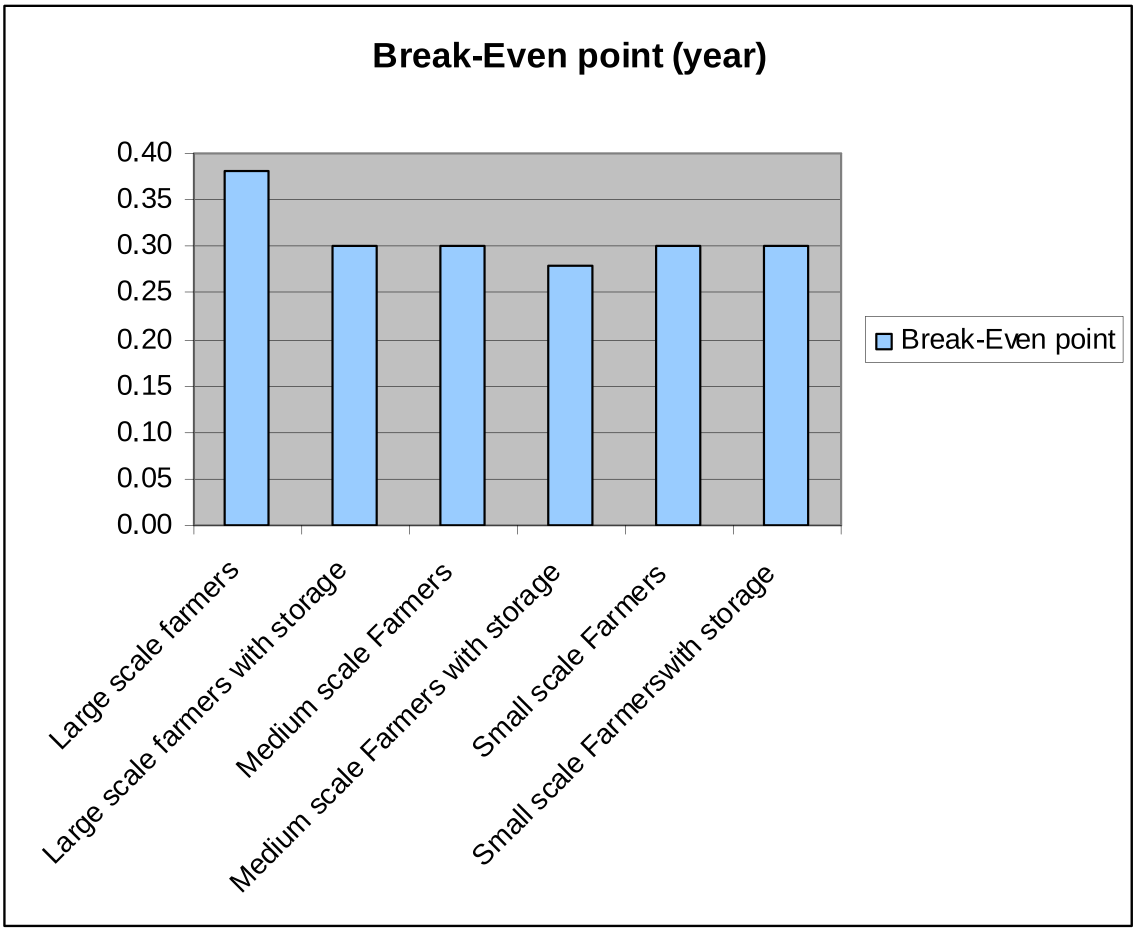


Figure 7 comparative breakeven points of farmers between current operation of the supply chain without storage and hypothetical scenario with storage facility

5.2 Cost-Benefit Analysis at traders level

Table 3 shows the gross profit generated by the wholesalers and retailers based on the interview data collected. The result indicates that the postharvest losses in small wholesalers amount to more than 25% of their tomato while retailers experience a loss of more than 35% of their sale. In addition the purchases of the tomato from farmers constitute the larger portion of their variable cost (refer to Appendix 5).

It can be identified, from the Table 3, that the use of storage in small wholesale shops and retailers had largely reduced their variable costs, had increased their revenue, and thereby their profit. The breakeven analysis associated with installing the storage can be compensated by the avoided losses (which in this scenario is assumed to have reduced 80% of the total losses). When comparing the current storage practices of these traders with that of the scenario with storage facility, the breakeven point is slightly lower (figure 8), however, still the breakeven point in the scinarios with storage is short. e (refer to appendix 8),

Table 3 summary of cost benefit analysis of wholesalers and retailers under current operation of supply chain without proper storage and a hypothetical scenario with proper storage facility

Costs (Nakfa)	Small Wholesalers		Retailers	
	Without Storage	With Storage	Without Storage	With Storage
Fixed Cost	213,333	493,333	162	4,475
Variable Cost	4,047,000	3,100,500	55,163	42,553
Total Cost	4,260,333	3,593,833	55,324	44,214
Total revenue	4,800,000	5,040,000	64,363	70,460
Profit/Loss	753,000	1,939,500	9,200	27,908
Breakeven Point (yr)	0.28	0.25	0.02	0.16

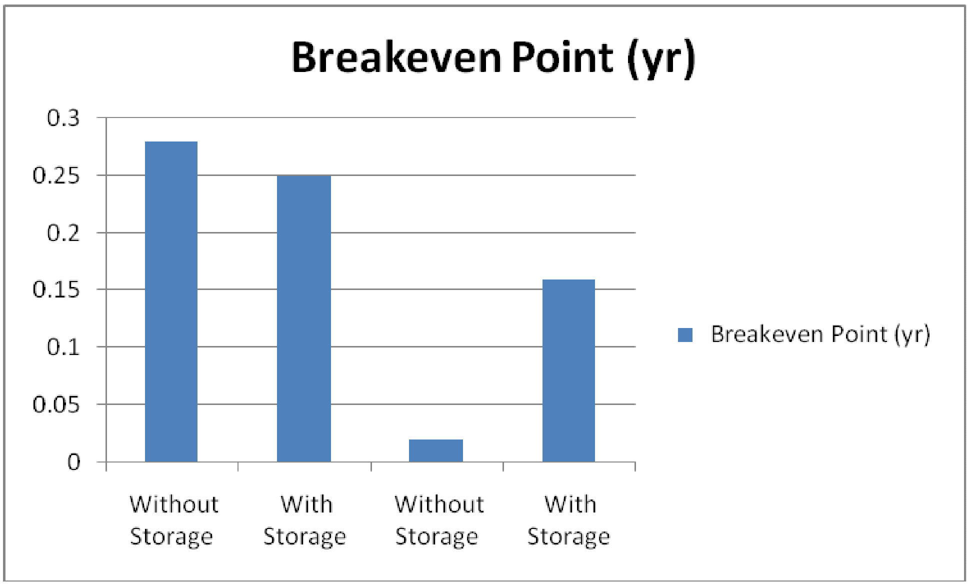


Figure 8 comparative breakeven points of wholesalers and retailers between current operation of the supply chain without storage and hypothetical scenario with storage facility

CHAPTER 6
DISCUSSION

In this chapter the supply chain of tomato in Eritrea with regards to storage system is discussed. The absence of storage in tomato supply chain of Eritrea is found to be one of the factors contributing to tomato postharvest losses. The loss of tomato can be reduced by storing tomato in proper storage that prolongs the shelf life of tomato.

6.1 Supply chain analysis

As it is mentioned in chapter 4 large scale farmers in Eritrea stored their tomato in a big warehouse without any storage facilities. Due to large quantities of tomato harvest that is beyond the demand of the market at the harvest season, the excess tomato harvested should be stored. In addition, the excess supply of tomato in the market results in low prices. However, the perishable nature of tomato stored at room temperature, resulted in large quantities of post harvest losses. The findings of this study showed that there is large amount of post harvest losses that is accounting for more than 8% in the farmer level. Similarly Mohammedbirha (2008) has reported about 15 – 30% postharvest loss of tomato in Eritrea, mainly contributed by lack of proper storage facilities. This study further found out that medium and small scale farmers also have large quantities of post harvest losses that could easily be reduced by implementing proper storage facilities.

The storage of tomato in big warehouses at room temperature that was found as being practiced in large scale farmers of Eritrea resulted in large post harvest losses due to spoilage of tomato. According to Irtwange (2006), since many fruits and vegetables including tomato are highly perishable in nature that their storage at room temperature favors decay, mass loss, and softening, wilting, and off-flavor development.

Storage technologies are not new to world agriculture. It is clear from the loss of large quantities of harvest in farmers of Eritrea that storage is an essential means of reducing the postharvest losses, which leads to financial loss. Many countries in the world use different kinds of technologies that finding suitable storage facility suiting the needs of the farmers and traders is not difficult. For example, in India large scale framers store their tomato produce in a cold storage building. According to The Hindu newspaper (2006) tomato, being a perishable commodity, was being sold at cheaper prices by Indian farmers before the introduction of storage facilities. After the establishment of cold storage facilities by the Government, farmers are now able to preserve their produce during the lean period thereby availing lower prices.

The availability of a storage facility to Eritrean farmers can also allow them to store their produce when the price is too low and sell their produce slowly at market prices that hurriedly selling it at bottom-hit prices. Farmers indicating the source of finance in small scale farmers to install the traditional storage system were large as compared to their capital capacity

From the findings of the interview, small scale farmers in Eritrea had devised a traditional way of cooling their tomato by covering the crates with wet sac until the tomato is delivered to the market. This system is however efficient only for small period of time that continuously covering it with wet cloth can interfere with the proper respiration of ripening tomato and may also harbor disease organisms. Therefore, alternative low-cost storage methods, such as the use of simple evaporative cooler (EC), is necessary particularly for small farmers. Acedo (1997) found it effective for small scale farmers and traders, who dominate the fruit and vegetable industry in developing countries, to use EC. Evaporative cooling system maintains a cool and humid environment around the produce as the heat from the storage chamber is dissipated with the evaporation of water. The decrease in temperature is usually small but the increase in humidity could be substantial, so that deterioration due to moisture loss is retarded.

The result of the interview showed that retailers most of them operate in small quantities stored their tomato in household refrigerator to preserve the tomato till they sale it to customers. However due to moisture loss during storage, quality of the tomato was lowered as the day of storage was increased. According to Quisqualis (2008), there is always some moisture loss from fruits and vegetables during cold storage but excessive moisture loss is a problem that is observed during storage without proper packaging. The problem could be prevented by keeping the humidity of air in the store above 85%. Alternatively, moisture loss can be reduced by allowing the crop to cool to the storage temperature and then covering it in plastic before storage. It is also important to maintain an adequate circulation of air using fans, and tomatoes have to be, therefore, stacked in ways that enable air to circulate freely around all sides. Such storage facility use in retailers was found to be cost effective in this study using the hypothetical cost benefit analysis of a retailer shop that operated with proper storage.

6.2 Cost benefit analysis of storage

From the analysis in chapter 5, cold storage was proposed for the large- and medium-scale farmers and evaporative cooling system for the small scale farmers based on their production capacity. The operation of large and medium scale farmers is similar to the production capacity of modern agricultural operation in the other parts of the world that, suitable storage facility such as cold storage is a requirement. On the other hand, the use of cold storage facility for small scale farmers is not suitable due to the absence of electrical power supply in their area of farming (MBendi 2009). With alternative source of electricity, such as solar or wind power, storage facilities can be operated in such areas, with the support of lending agencies for the investment of the storage equipment. However, technologies of such alternative power supply sources are not available at present and their introduction in the country is not seen in the near future. Therefore, for the purpose of comparing the cost-benefit storage facility in small scale farmers, technology used in India that operates with evaporative cooling system and that can easily be implemented in Eritrea was chosen in this hypothetical scenario. Furthermore, this study is based on the assumption of implementing a cold storage in large and medium scale farmers and the tomato traders for the cost benefit analysis scenario with storage facility. Although there exist other storage facilities, are more advance than cold storage, the study here is attempting to tackle the problem of storage of tomato in Eritrea that it is looking at the applicability of the storage under the local condition. According to Verma and Joshi (2000) hypobaric storage and CA storage needs some requirements such as:

- Construction of the room should have adequate insulation and vapour barrier, enough cooling surface to ensure high humidity and air circulation to cool the fruit in the reasonable time.
- CA storages require more refrigeration capacity than cold storage.

These requirements ask additional costs that would not be attractive for farmers to invest in storage facility. Therefore this study considered only one scenario of investment with cold storage in all the supply chain except that of evaporative cooling system from India to small-scale farmers. Cold storage facility system has been introduced the country for the storage of marine products by the EMPC (Eritrean Marine Product Company).

6.3 Risk analysis of storage facilities

Electric Supply: In Eritrea the unstable electric supply could be one of the risk factor for implementing storage facility. According to Quisqualis (2008) during cold storage if the power of electricity is not stable the temperature of the cold room will be fluctuated, affecting the quality of the tomato. In addition, due to remote locations of tomato farms, availability electric supply in these regions could be a challenge in Eritrea, especially in the case of small scale farmers.

Operating cost: The profitability of storage facilities can also be influenced by the fluctuations in harvest of and demand for tomato. Higher cost incurred due to operating a storage facility in times of low productivity and/or higher market demand can lead to low profit for the farmer and wholesalers.

Adoption of change: Most technological innovations have helped humanity since long time. The introduction of new technology however takes long time for its adoption in closed communities like Eritrea. The introduction and implementation of new storage facilities such as EC in small scale farmers could be a challenge.

CHAPTER 7

CONCLUSION AND RECOMMENDATION

7.1 Conclusions

From the literature found it can be concluded that there are different technological innovations of storage facilities. And this technologies have high contribution in the extending the shelf life of tomato. Therefore, it is imperative that for reducing post harvest losses and thereby increasing financial benefits of farmers and traders in Eritrea, storage facilities need to be implemented. As shown in this study, the implementation of storage facility has resulted in more financial gain to both farmers and traders that it can be concluded, based on financial terms, that storage facilities in Eritrea can be feasible.

The research also examined the storage systems in the tomato supply chain of Eritrea. The supply chain was found to have no storage techniques apart the retailers who keep their tomato in the refrigerator and the traditional wet sac covering of small scale farmers, which was not effective in maintaining tomato for a longer period of time. Such storage facilities are found to be ineffective in view of the current postharvest losses. Therefore, this study concludes that having proper storage facility in all the farmers and traders which is technologically up-to-date can reduce the post harvest losses. This in turn, will result in financial gains which is bigger that the initial investment needed for the implementation of the storage facilities.

7.2 Recommendations

In this study the economics of the storage facility was analyzed, however there is a need of further research on the implementation of the storage feasibility (i.e. the environmental, social, and political aspect). However, based on the information obtained, the study was able to make the following recommendations.

- Farmers as well as traders of tomato in Eritrea should install and implement a storage facility in their activity. This will increase their revenue, despite of the requirement for initial investment. However, informed decision need to be made which storage facility is suitable for each actor in the supply chain supported by pilot projects run by the government bodies. This can help save money by avoiding unsuitable investments in equipments and material. Government bodies can be involved in assessing the benefit of having technologically advanced storage facilities in view of political, socio-economic and environmental parameters in small pilot projects before implementations. This can help avoid huge investment decisions by farmers that might lead to unacceptable and environmental unfriendly technology that can lead to the demise of the farmers or traders involved.
- It is recommended that the government authorities give attention to the activities of the small scale farmers and give support to them, especially in the introduction and financing of evaporative cooling facilities that is more suitable for their tomato storage. This can help in achieving the bigger goal of economic and social benefit, while generating wealth and employment to the community. These are the bigger goals of social development plans of the government that is based on social equity. As big farmers are already subsidized by the government for the reasons of reducing prices to the community, large number of farmers who are also working hard for their livelihood need to be supported by granting them long term loan and training.
- The supply chain of tomato has not been investigated before therefore identifying critical points in the supply chain that needed improvement is difficult. This study is the first of its kind focused mainly in storages from data collected by interviews and literature. However, further assessments are necessary in mapping and identifying the supply chain with more

details and scope. Investigations regarding the social acceptability and environmentally sound technology are one that needs to be considered, In addition, many financial support systems need to be designed to support farmers and traders in different levels. The future investigation should also make use of results from the pilot projects made in the field on the feasibility of implementing storage facility.

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APPENDIX 1
INTERVIEW QUESTIONS

The details of the costs were asked directly to the farmers, wholesalers and retailer as it is shown in the next appendices. However the detailed question are not mentioned in this part.

Open interviews with farmers

1. What is your area of production?
2. What are your costs of tomato production?
3. What is your selling price?
4. Where do you get your inputs (seed, Fertilizer and pesticides)?
5. Where do you sell your tomato?
6. How do you transport the tomato?
7. Who is supporting or influencing your tomato production?
8. How much is the loss of tomato due to storage problems (in terms of weight or money estimated percentage losses)?
9. How do you storage your tomato?

Open interview with wholesalers and retailers

1. From where do you purchase the tomatoes?
2. Where do you sell the tomato?
3. What are the roles of stakeholders on their tomato supply chain? (Who are supporter and influencer of the tomato chain and how does they support or influence?
4. How do you store your purchased tomatoes?
5. How much is the loss of tomato due to storage problems (in terms of weight of money)?
6. What are the main costs for tomato marketing?

APPENDIX 2
PRODUCTION PLAN OF TOMATO: LARGE SCALE FARMERS IN ERITREA

	Molover Farm	Elabered Farm	Sawa-Afhimbole farm	Halhale farm	Average
Production (kg/ha/ crop)	50,000	45,000	60,000	35,000	47,500
Area cultivated (ha)	36	30	42	30	35
Number of crops per year	3	3	3	3	3
Total production (kg /year)	5,400,000	4,050,000	7,560,000	3,150,000	5,040,000
Selling price per kg	5	8	6	7	7
Revenue/ farm/kg /year)	27,000,000	32,400,000	45,360,000	22,050,000	31,702,500
Price of seed per ha(Nakfa)	500	500	500	500	500
Total price of seed/ farm/year	54,000	45,000	63,000	45,000	51,750
Fertilizer kg per ha	100	100	120	100	105
Fertilizer price per kg	10	10	10	10	10
Number of fertilizer application per crop	3	3	3	3	3
Price of fertilizer per crop	3,000	3,000	3,600	3,000	3,150
Price of fertilizer / ha/year	9,000	9,000	10,800	9,000	9,450
Price of fertilizer per farm per year	324,000	270,000	453,600	-	261,900
Pesticides used liter/ ha	1	1	2	1	1
pesticide price per liter	367	367	367	367	367
Pesticides price per crop/ ha	367	336	825	336	466
Pesticides price per ha per year	1,100	1,008	2,475	1,008	1,398
Pesticides price per farm per year	39,600	30,250	103,950	30,250	51,013
Weeding salary per month per person	1,000	1,000	1,000	1,000	1,000
Numbers of weeding workers	50	30	68	20	42
Total weeding price per year	150,000	90,000	204,000	60,000	126,000
Harvesting price per month/person	1,000	1,000	1,000	1,000	1,000
Numbers of harvester workers	50	30	68	20	42
Total harvesting price per year	150,000	90,000	204,000	60,000	126,000
Estimated % of post harvest losses	N/A	15%	10%	N/A	13%
Post harvest losses kg per farm	N/A	607,500	756,000	N/A	681,750
Price of harvest losses/ farm/ year	N/A	4,860,000	4,536,000	N/A	4,698,000
Transportation per 10 tones	2,000	2,000	2,000	2,000	2,000

Transportation cost/year	1,080,000	810,000	1,512,000	630,000	1,008,000
Soil preparation per ha	2,500	2,500	2,500	2,500	2,500
Soil preparation per farm/crop	90,000	75,000	105,000	75,000	86,250
Soil preparation per year/farm	270,000	225,000	315,000	225,000	258,750
Nursery preparation per ha	500	501	502	503	502
Nursery preparation per farm/crop	18,000	15,030	21,084	15,090	17,301
Nursery preparation per year/farm	54,000	45,090	63,252	45,270	51,903
Transplanting per ha	2,000	2,000	2,000	2,000	2,000
Transplanting per farm/crop	72,000	60,000	84,000	60,000	69,000
Transplanting per farm/year	216,000	180,000	252,000	180,000	207,000
Number of Laborer	20	22	31	20	23
Salary/month	1,500	1,200	1,500	1,000	1,300
Salary/year	360,000	316,800	558,000	240,000	368,700

APPENDIX 3
PRODUCTION PLAN OF TOMATO: MEDIUM SCALE FARMERS IN ERITREA

	Zoba Gash Barka			Zoba Debub			Zoba Anseba			
Medium scale farmers	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6	Farmer 7	Farmer 8	Farmer 9	Average
Production (kg/ha/ crop)	42,000	40,000	28,000	34,000	25,000	30,000	35,000	30,000	35,000	33,222
Area cultivated (ha)	20	18	22	15	18	12	10	14	16	16
Number of crops per year	3	3	3	2	2	2	2	2	3	2
Total production (kg /year)	2,520,000	2,160,000	1,848,000	1,020,000	900,000	720,000	700,000	840,000	1,680,000	1,376,444
Selling price per kg	9	9	9	7	7	7	8	8	8	8
Revenue/ farm/kg /year)	22,680,000	19,440,000	16,632,000	7,140,000	6,300,000	5,040,000	5,600,000	6,720,000	13,440,000	11,443,556
Price of seed per ha(Nakfa)	500	500	500	500	500	500	500	500	500	500
Total price of seed/ farm/year	30,000	27,000	33,000	15,000	18,000	12,000	10,000	14,000	24,000	20,333
Fertilizer kg per ha	100	100	90	100	90	80	100	90	100	94
Fertilizer price per kg	10	10	10	10	10	10	10	10	10	10
Number of fertilizer application per crop	3	3	3	3	3	3	3	3	3	3
Price of fertilizer per crop	3,000	3,000	2,700	3,000	2,700	2,400	3,000	2,700	3,000	2,833
Price of fertilizer / ha/year	9,000	9,000	8,100	6,000	5,400	4,800	6,000	5,400	9,000	6,967
Price of fertilizer per farm per year	180,000	162,000	178,200	90,000	97,200	57,600	60,000	75,600	144,000	116,067
Pesticides used liter/ ha	1.2	0.8	0.3	0.4	0.3	0.4	0.5	0.5	0.7	0.6
pesticide price per liter	367	367	367	367	367	367	367	367	367	367
Pesticides price per crop/ ha	428	299	122	159	119	159	183	183	244	211
Pesticides price per ha per year	1,283	898	367	318	238	318	367	367	733	543
Pesticides price per farm per year	25,667	16,170	8,067	4,767	4,290	3,813	3,667	5,133	11,733	9,256
Weeding salary per month per person	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Numbers of weeding workers	34	28	26	17	32	15	13	20	28	24
Total weeding price per year	34,000	28,000	26,000	17,000	32,000	15,000	13,000	20,000	28,000	23,667
Harvesting price per month/person	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Numbers of harvester workers	34	35	26	17	32	15	13	20	28	24
Total harvesting price per year	34,000	35,000	26,000	17,000	32,000	15,000	13,000	20,000	28,000	24,444
Estimated % of post harvest losses	10%	8%	7%	5%	10%	10%	2%	8%	10%	8%
Post harvest losses kg per farm	252,000	172,800	129,360	51,000	90,000	72,000	14,000	67,200	168,000	112,929
Price of harvest losses/ farm/ year	2,268,000	1,555,200	1,164,240	357,000	630,000	504,000	112,000	537,600	1,344,000	941,338
Transportation per 10 tones	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Transportation cost/year	504,000	432,000	369,600	204,000	180,000	144,000	140,000	168,000	336,000	275,289
Soil preparation per ha	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Soil preparation per farm/crop	50,000	45,000	55,000	37,500	45,000	30,000	25,000	35,000	40,000	40,278
Soil preparation per year/farm	150,000	135,000	165,000	75,000	90,000	60,000	50,000	70,000	120,000	101,667
Nursery preparation per ha	500	501	502	503	504	505	506	507	508	504
Nursery preparation per farm/crop	10,000	9,018	11,044	7,545	9,072	6,060	5,060	7,098	8,128	8,114
Nursery preparation per year/farm	30,000	27,054	33,132	15,090	18,144	12,120	10,120	14,196	24,384	20,471
Transplanting per ha	2,000	2,001	2,002	2,003	2,004	2,005	2,006	2,007	2,008	2,004
Transplanting per farm/crop	40,000	36,018	44,044	30,045	36,072	24,060	20,060	28,098	32,128	32,281
Transplanting per farm/year	120,000	108,054	132,132	60,090	72,144	48,120	40,120	56,196	96,384	81,471
Number of Laborer	10	11	9	9	9	5	6	6	9	8
Salary/month	1,200	1,000	1,000	1,500	1,200	1,000	1,000	1,000	1,000	1,100
Salary/year	144,000	132,000	108,000	162,000	129,600	60,000	72,000	72,000	108,000	109,733

APPENDIX 4
PRODUCTION PLAN OF TOMATO: SMALL SCALE FARMERS IN ERITREA

	Zoba Maekel			Zoba Debub			Zoba Anseba			
	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6	Farmer 7	Farmer 8	Farmer 9	Average
Production (kg/ha/ crop)	7,000	6,000	9,000	13,000	4,000	7,000	3,000	8,000	6,000	7,000
Area cultivated (ha)	2	1	4	3	2	2.5	1	1.5	4	2
Number of crops per year	2	2	2	2	2	2	2	2	2	2
Total production (kg /year)	28,000	12,000	72,000	78,000	16,000	35,000	6,000	24,000	48,000	35,444
Selling price per kg	5	5	5	5	5	6	7	6.5	7	5
Revenue/ farm/kg /year)	140,000	60,000	360,000	390,000	80,000	210,000	42,000	156,000	336,000	197,111
Price of seed per ha	500	500	500	500	500	500	500	500	500	500
Total price of seed/ farm/year	2,000	1,000	4000	3,000	2,000	2,500	1,000	1,500	4,000	2,333
Fertilizer used kg per ha	50	30	60	70	20	60	0	50	N/A	43
Fertilizer price per kg	10	10	10	10	10	10	10	10	N/A	10
Number of fertilizer applied per crop	2	2	2	3	1	2	0	2	N/A	2
Price of fertilizer per crop	1,000	600	1,200	2,100	200	1,200	0	1,000	N/A	913
Price of fertilizer / ha/year	2,000	1,200	2,400	4,200	400	2,400	0	2,000	N/A	1,825
Price of fertilizer per farm per year	4,000	1,200	9,600	12,600	800	6,000	0	3,000	N/A	4,650
Pesticides per liter/ ha	0.7	0.4	0.6	0.8	0.5	0.5	0.3	0.5	0.5	1
Pesticides price per liter	367	367	367	367	367	367	367	367	367	367
Pesticides price per crop	244	153	229	306	183	183	92	183	183	195
Pesticides price per ha per year	489	306	458	611	367	367	183	367	367	390
Pesticides price per farm per year	978	306	1,833	1,833	733	917	183	550	1,467	978
Estimated % of post harvest losses	10%	8%	11%	15%	12%	9%	10%	10%	N/A	11%
Post harvest losses kg per farm	2,800	960	7,920	11,700	1,920	3,150	600	2400	N/A	3,931
Price of harvest losses/ farm/ year	14,000	4,800	39,600	58,500	9,600	18,900	4,200	15,600	N/A	20,650
Transportation per 10 tones	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Transportation cost/year	5,600	2,400	14,400	15,600	3,200	7,000	1,200	4,800	9,600	7,089

APPENDIX5
ROW DATA OF WHOLESALERS AND RETAILER

	Halhale farm wholesaler	Gash-afhimbole farm wholesaler	Big Whole salers Average	wholesaler 1	wholesaler 2	Wholesalers Average	Retailer 1	Retailer 2	Retailer 3	Retailer 4	Retailer Average
Labour cost per month	1,000	1,000	1,000	800	800	800					
Numbers of labourer	10	15	13	3	2	3					
Total labour cost per year	10,000	15,000	12,500	2,400	1,600	2,000					
House rent cost per month	5,000	7,000	6,000	3,000	4,500	3,750	1,500	N/A	800	800	1,033
House rent cost per year	60,000	84,000	72,000	36,000	54,000	45,000	18,000	N/A	9,600	9,600	12,400
Tomato purchase cost per kg	7	6	6,50	7	7	7	15	7	15	7	11
Tomato selling price	9	7	8,00	15	15	15	27	25	26	25	26
Total amount of tomato purchased/year	3,150,000	7,560,000	5,355,000	450,000	350,000	400,000	3,000	2,500	2,500	2,500	2,625
Total cost of purchasing tomato/yr	22,050,000	45,360,000	33,705,000	3,150,000	2,450,000	2,800,000	45,000	17,500	37,500	17,500	29,375
Transportation							1,650	960	3,360	3,360	2,333
Percentage of Losses	25%	30%	28%	20%	20%	0.2	5%	5%	5%	5%	0.05
Losses in Kg/ year	787,500	2,268,000	1,527,750	90,000	70,000	80,000	150	125	125	125	132
Cost of the Losses/yr	7,087,500	15,876,000	11,481,750	1,350,000	1,050,000	1,200,000	4,050	3,125	3,250	3,125	3,388
Total Revenue	28,350,000	52,920,000	40,635,000	6,750,000	5,250,000	6,000,000	81,000	62,500	65,000	62,500	67,750

APPENDIX 6
COST-BENEFIT OF FARMERS WITHOUT STORAGE

Costs		Large-scale Farms	Medium-scale Farm	Small-scale Farms
Fixed cost				
	Farm equipment	700.000	500000	2000
	Tractor	3000000	1000000	0
	Family labour	0	0	4500
	Well preparation	100000	30000	10000
	Pump	950000	200000	2000
	Crate Box	2.688.000	856.395	26.133
			-	-
Total Fixed cost		7.438.000	2.586.395	44.633
Variable cost		-	-	-
	Hired Labour	368.700	109.733	-
	Soil preparation	258.750	101.667	-
	Nursery preparation	51.750	20.333	-
	Transplanting	207.000	81.333	-
	Weeding	126.000	23.667	-
	Watering/irrigating	200.000	60.000	9.000
	Harvesting	126.000	24.444	-
	Transportation	1.008.000	275.289	7.089
	Fertilizer	329.400	116.067	4.650
	Pesticides	51.013	9.256	978
	Seeds	51.750	20.333	2.333
Wholesale variable cost	Warehouse rent	72.000	-	-
	Hired Labour	12.000	-	-
	Utility expense	10.000	-	-
Sub Total		2.872.363	842.123	24.050
	Post harvest losses	4.698.000	941.338	20.650
Sub Total				

		4.698.000	941.338	20.650
Total Variable		7.570.363	1.783.461	44.700
Total Cost		15.008.363	4.369.856	89.333
Revenue				
Tomato sale		27.004.500	10.502.218	176.461
Total Revenue		27.004.500	10.502.218	176.461
Profit/Loss		19.434.138	8.718.757	131.761
Break even point		0.4	0.3	0.3

APPENDIX 7
COST-BENEFIT OF FARMERS UNDER A HYPOTHETICAL SCENARIO OF PROPER STORAGE

Costs		Large-scale Farms	Medium-scale Farm	Small-scale Farms
Fixed cost				
	Farm equipment	700.000	500.000	2.000
	Storage Building	700.000	200.000	15.000
	Storage Machinery	400.000	80.000	-
	T ractor	3.000.000	1.000.000	-
	Family labour	-	-	4.500
	Well preparation	100.000	30.000	10.000
	Pump	950.000	200.000	2.000
	Crate Box	2.688.000	856.395	26.133
			-	-
Total Fixed cost		8.538.000	2.866.395	59.633
		-	-	-
Variable cost		-	-	-
	Labour/technician	5.500,0	3.500,0	1.000,0
	Electricity/water	50.000,0	10.000,0	200,0
	Hired Labour	368.700	109.733	-
	Soil preparation	258.750	101.667	-
	Nursery preparation	51.750	20.333	-
	Transplanting	207.000	81.333	-
	Weeding	126.000	23.667	-
	Watering/irrigating	200.000	60.000	9.000
	Harvesting	126.000	24.444	-
	Transportation	1.008.000	275.289	7.089
	Fertilizer	329.400	116.067	4.650

	Pesticides	51.013	9.256	978
	Seeds	51.750	20.333	2.333
wholesale variable cost	Warehouse rent	72.000	-	-
	Hired Labour	12.000	-	-
	Utility expense	10.000	-	-
		-	-	-
Sub Total		2.927.863	855.623	25.250
	Post harvest losses (80% reduction assumed)	939.600	188.268	4.130
Sub Total		939.600	188.268	4.130
Total Variable		3.867.463	1.043.891	29.380
Total Cost		12.405.463	3.910.286	89.013
Revenue				
tomato sale		30.762.900	11.255.288	192.981
Total Revenue		30.762.900	11.255.288	192.981
Profit/Loss		26.895.438	10.211.397	163.601
Breakeven Point (yr)		0.30	0.28	0.3

Calculation of cost of carte

Crate	Big Wholesalers	Small Wholesalers	Retailers	Medium scale Farmers	Small-scale farmers
Capacity of crate	50	50	50	50	50
No. Required/crop harvest	100,800	8,000	53	10,705	327
Price of 1 crate	80	80	80	80	80
reuse per year	3	3	26		
Total Price	2,688,000	213,333	162	856,395	26,133

APPENDIX 8
COST-BENEFIT OF WHOLESALER AND RETAILER WITHOUT STORAGE

		Small Wholesalers	Retailers
Fixed Cost			
	Crates	213,333	162
Total Fixed Cost		213,333	162
Variable Costs			
	Labour	2,000	-
	Warehouse rent	45,000	12,400
	Tomato Purchases	2,800,000	39,375
	Tomato Loss	1,200,000	3,387
Total Variable Cost		4,047,000	55,162
Total Cost		4,260,333	55,324
Revenue			
	Tomato sale	4,800,000	64,362
Total revenue		4,800,000	64,362
		-	-
Profit/Loss		753,000	9,200
		-	-
Breakeven Point (yr)		5.7	6.0

APPENDIX 9
COST-BENEFIT OF WHOLESALER AND RETAILER WITH A SCENARIO OF PROPER STORAGE

		Small Wholesalers	Retailers
Fixed Cost			
	Storage Building	6.650	1,500
	Storage Machinery	8.000	2,813
	Crates	213.333	162
Total Fixed Cost		227.983	4,475
		-	-
Variable Costs		-	-
	Labour/technician	3,500	-
	Electricity/water	10,000	100
	Labour	2,000	-
	Warehouse rent	45,000	12,400
	Tomato Purchases	2,800,000	29,375
	Post harvest losses (80% reduction assumed)	240,000	678
Total Variable Cost		3,100,500	42,553
		-	-
Total Cost		3,328,483	47,027
Revenue		-	-
	Tomato sale	6,960,000	70,460
Total revenue		6,960,000	70,460
		-	-
Profit/Loss		3,859,500	27,908
		-	-
Breakeven Point (yr)		0.86	1.69