FINANCIAL VIABILITY AND ADOPTION OF THE ZECC TECHNOLOGY FOR TOMATO STORAGE IN SAVELUGU AND SAGNARIGU MUNICIPALITIES IN THE NORTHERN REGION OF GHANA

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN AGRIBUSINESS

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DECLARATION

I, Eunice Ama Essel, the author of this thesis titled, "Financial Viability and Adoption of the ZECC Technology for Tomato Storage in Savelugu and Sagnarigu Municipalities in the Northern Region of Ghana" do hereby declare that, except for the references which have been duly acknowledged, this thesis was done entirely by me in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon from August 2017 to July 2018. This work has never been presented either in whole or in part for any other degree of this University or elsewhere.

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This thesis has been presented for examination with our approval as supervisors.

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(Co-supervisor)

DEDICATION

I dedicate this work to God Almighty for His guidance and protection; my beloved husband (Mr. Reuben Nartey), my lovely Essel family, and my special friends (David and Elsie Adomako-Kotei) for the love and support given throughout the period of my study.

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ABSTRACT

Zero Energy Cool Chamber (ZECC) storage technology is the use of an evaporative cool chamber for maintaining low temperature of fruits and vegetables compared to field, shed and room temperature. In order to help farmers and traders, the ZECC technology was introduced in the Savelugu and Sagnarigu municipalities. However, only a few of the farmers and traders have adopted it in these municipalities. Although the ZECC seems to be a means to help solve storage challenges, the validity of the farmers' and traders' perception of high cost relative to returns in the usage of the ZECC cannot be ascertained. This study, therefore, sought to examine the levels of awareness and usage of the ZECC, compare the net benefits of the ZECC with the existing storage method, the factors that would influence them in adoption of the ZECC, and finally identify constraints that affect farmers and traders in using the ZECC. A multistage sampling method was employed to select 210 farmers and traders in the municipalities. The study used descriptive statistics such as frequencies, percentages, likert scale, the benefit-cost analysis, probit, and the Kendall's coefficient of concordance (W) to address the objectives. Findings indicated that 83.33% of the respondents were aware of the ZECC technology but 26.19% have adopted the ZECC. The study revealed an NPV of GHS6, 436.15 and BCR of 1.52 for ZECC; and an NPV of GHS2, 699.41 and BCR of 1.09 for the existing method at 21% discount rate. With the exception of location, marital status and age, remaining factors were statistically significant to influence adoption of the ZECC. Among the constraints identified, access to credit and animal disturbances were ranked as the first and second most pressing constraints, respectively for farmers. High cost of transportation and high cost of storage were the first two most pressing constraints, in order of priority for traders. In conclusion, most of the respondents were aware of the ZECC but do not see the need for its usage, even though the ZECC proves to be more cost effective. It is, therefore, recommended, among others, that agricultural training institution and NGOs should organize sensitization programmes and training sessions for farmers and traders on the ZECC. Additionally, developmental agencies should tailor their development plans and projects towards addressing these challenges that hinder the ZECC usage in the Northern Region of Ghana.

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LIST OF ACRONYMS

BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
CBR	Cost Benefit Ratio
FAO	Food and Agricultural Organization
FOASTAT	Food and Agriculture Organization Corporate Statistical Database
GBO	Group Based Organization
GLSS	Ghana Living Standards Survey
GSS	Ghana Statistical Service
Hort (CRSP)	Horticulture Collaborative Research Support Program
MoFA	Ministry of Food and Agriculture
NGO	Non-Governmental Organization
NPV	Net Present Value
SSA	Sub-Saharan African
TMS	Traditional Method of Storage
USAID	United States Agency of International Development
ZECC	Zero-Energy Cool Chamber

CHAPTER ONE

INTRODUCTION

1.1 Background

In the quest to reduce post-harvest losses, solve problems with food quality, safety and nutrition, and improve the livelihood of farmers and traders in the agricultural sector at the global level, Roy and Khurdiya (1983) invented the Zero-Energy Cool Chamber (ZECC) storage technology at New Delhi, India in the 1980s. They indicated that it has a potential of reducing the level of fruits and vegetable losses. The ZECC is an evaporative cool chamber which maintains considerably and relatively low temperature of fruits and vegetables compared to field, shed and room temperature, that will prolong the shelf life of the fruits and vegetables (Dubey, Roy, Saran & Raman 2013). The ZECC storage technology has been tested and proven to be safe and of good quality over the years (Kirk, 2014).

In view of the ZECC storage technology quality, a pilot program was introduced in 2012 by the USAID in collaboration with the Horticulture Collaborative Research Support Program Hort (CRSP) to help solve issues related to physical losses of horticultural crops after harvesting, which continues to range from 30-80% in the Sub Saharan Africa (SSA). The Hort (CRSP), MoFA and other stakeholders have contributed tremendously towards the implementation of the ZECC in the Northern region of Ghana during the major training on the ZECC storage in Tanzania (Kitinoja & Barrett, 2015). This was with the aim of sustaining fruits and vegetables production and storage system in the rural communities in the Sub Saharan African countries.

The implementation of Hort (CRSP)'s objectives led to the construction of about five(5) demonstration sites of the ZECC storage technology to enhance farmers' and traders' training on the usage of the ZECC for storage of their produce (tomato most especially) in the Northern region. Over the years, smallholder tomato farmers and petty traders rely on the traditional method of storage (TMS) at the Savelugu and Sagnarigu municipalities.

However, challenges associated with the off-farm storage and high post-harvest losses, boosted the Hort (CRSP) to promote the use of the ZECC storage technology. The ZECC storage technologies together with other cooling evaporative systems are appropriate for the storage of high value crops such as vegetables and/or fruits (Roy and Pal, 1988). ZECC has a better evaporative cooling system for prolonging shelf-life of the produce after harvest. According to Singh, Singhrot, Sharma and Sadooja (1987), using the ZECC storage technology could reduce water loss of fruits and/or vegetables and retain the fruits and or vegetables freshness during storage. ZECC system has several justifications in relation to its benefits and usage in the Sub-Saharan African countries.

The need for the usage of the ZECC was identified when the Ghana Statistical Survey (GSS) (2014), rendered the northern part of Ghana as the poorest in the country during their survey on poverty profiling in Ghana. It has, therefore, become necessary to promote the adoption of the ZECC storage technology in this part of the country. Furthermore, the high records on post-harvest losses of fruits and vegetables increases the level of diversity into other businesses by farmers and traders in the area.

Therefore, the need for appropriate, reliable, eco-friendly and low-cost storage technology coupled with increasing diversity of the tomatoes business in the Northern region calls for the development and adoption of improved agricultural storage technologies. ZECC storage technology promises a substantial increase in agricultural processing and storage especially for high water content fruits and vegetables like tomato and an increase in household income. The high temperatures and lack of access to cold storage facilities in West Africa contribute largely to the high perishability of fresh tomatoes (Robinson, Kolavalli, & Diao 2012).

Moreover, Robinson *et al.* (2012) reported that the shelf life of tomato is often less than a week due to the methods used in cultivating the tomato and the varieties grown. Small-scale farmers and petty traders using the ZECC are able to prolong the life span of fruits and vegetables for up to nine days by storing their produce in simple non-energy reliant cool chambers like the ZECC. According to Singh *et al*., (1987), the Zero Energy Cool Chamber storage technology does not require any form of power to run. This makes it convenient for off-the grid farmers and traders. It is in this light that USAID in collaboration with Hort (CRSP) came up with the pilot program in the municipalities to help train more facilitators that would impact on farmers and traders on the benefits of adopting the ZECC. Pal & Roy (1988) concluded that, a major key element to reduce poverty in our rural areas and enhance the agricultural sector especially hot climate areas is the adoption of the ZECC and other modernized technologies. This study, therefore, focuses on the adoption and test of viability for the ZECC storage technology in the Savelugu and Sagnarigu municipalities of the Northern region of Ghana.

1.2 Problem Statement

According to Sibomana, Workneh and Audain, (2016) the Sub-Saharan African (SSA) countries face a lot of post-harvest losses in the supply of freshly harvested tomato. These challenges are as a result of poor storage, handling, lack of cold storage facilities, and inadequate monitoring, among others, in the SSA countries. In most tropical countries, quality deterioration of horticultural produce including tomato occurs immediately after harvest due to lack of on-farm storage facilities and maintenance of low temperatures in fruits and vegetables including tomatoes (Sharma, Pal, Singh, Kar & Asrey, 2004)

Food and Agriculture Organization estimated that about 40% of farm fresh produce goes bad after harvesting and results in its perishability due to issues related to postharvest losses (MoFA, 2012). According to Kearney (2010), although farmers have increased tomato production levels over the past decade, proper technologies needed to avoid or reduce post-harvest losses particularly the rate at which tomatoes rot or perish has not been keenly given attention. This is evidenced by food losses occurring due to post-harvest losses and inadequate storage and marketing system (MoFA, 2012).

Current studies on tomato production and marketing of tomato in Ghana by Robinson & Kolavalli (2010) showed that, most of the vegetables and fruit farmers in the rural areas sell their produce to middle market woman just after the harvest. In some cases, the middle marketers come to harvest themselves after the price has been bargained between the farmers and traders.

Lack of good transportation systems or poor roads, inadequate energy supply, lack of investment in storage mostly results in lower price of vegetables and fruits during the peak harvesting season. Farmers in the remote areas mostly sell their produce in the local market at low prices to petty traders (Yeboah, 2011). Most farmers are unable to get the return of invested money of cultivating their vegetables or fruits. As a result, a high percentage of poverty level still remains in such rural areas. Additionally, traders in these areas are unable to sell all their tomatoes among other vegetables and fruits during market days. Storage of these left overs becomes a headache to the traders due to the high cost involved in cold chain storage. Inability to store leftovers also results in early deterioration of the leftover tomatoes causing losses to the traders.

Considering acute energy crisis, high costs involved in the usage of refrigerators and lack of cold storage facilities in remote areas like the northern regions of Ghana, the adoption of new technologies become crucial. In most cases, whenever there is the introduction of new technologies in rural areas, smallholder farmers and traders are unwilling to adopt that particular technology, but continue to apply their old methods (Kitinoja & Barrett, 2015). The unwillingness of farmers and traders to adopt new technologies has been observed in the Savelugu and Sagnarigu municipalities. Very few farmers and traders in these municipalities have adopted the ZECC storage ever since its introduction. This is as a result of their perception of high costs involved in the adoption of the ZECC storage technology.

Although studies consider the ZECC storage technology as a low cost storage system which does not require electricity for operating (Islam *et al.,* 2014); there is no documentation on the financial viability of the technology in the Savelugu and Sagnarigu municipalities to substantiate or otherwise the perception of the farmers and traders on the costs and returns involved in the usage of the ZECC. Sufficient information on farmers' and traders' unwillingness to adopt the ZECC and cost-benefit analysis is necessary for the formulation in tomato storage. In order to ascertain or otherwise the perceived high cost involved in adopting the ZECC storage technology. It is appropriate to know whether it is viable to use the ZECC for storage. This would inform farmers' and traders' decision to either adopt or continue to use the existing method of storage. Knowledge on the viability of the ZECC will enable the few adopters (early adopters) to back up on the maximum and proper usage of the technology adopted, so that the rest (late adopters) will follow suite. Nzomoi, Byaruhanga, Maritim and Omboto (2007) indicated that it is apparent that potential and/or early adopters of every new technology always consider the financial implications of the technology.

To ensure full adoption of the ZECC, the early adopters would have to be updated on the amount of money needed for their technology, cost involved towards the operations and maintenance of the ZECC, and most importantly know whether they are making profit or not. This will help decrease the uncertainties about the ZECC storage.

Empirical information on the validity of the farmers' and traders' perception of high costs relative to returns in the usage of the ZECC technology cannot be ascertained and majority of farmers and traders continue to use the traditional method of tomato storage. Even though there are some studies conducted in other countries in relation to the ZECC adoption, there is no study specifically addressing the storage technology adoption in Ghana.

Factors that will compel them to adopt the ZECC still remain unknown. It is also observed that, all technologies come with impediments and/or constraints hindering their smooth adoption and ZECC cannot be an exception. It is, therefore, imperative to identify the constraints faced in the usage of the ZECC for tomato storage for policy direction.

This study is ultimately designed to provide empirical answers to the under listed research questions:

1. What is the level of awareness and usage of the ZECC storage technology among tomato farmers and traders in the Savelugu and Sagnarigu municipalities?
2. How do the net benefits of ZECC technology compare with the net benefits of the traditional method of storage in the study area?
3. What are the factors that influence the adoption of ZECC storage technology in the study area?
4. What constraints do farmers and traders face in using the ZECC technology in the study area?

1.3 Objectives of the Study

The general objective of the study is to assess the financial viability and adoption of the ZECC storage technology in the Savelugu and Sagnarigu municipalities in the Northern region. This was achieved through the following specific objectives:

1. To determine the level of awareness and usage of the ZECC storage technology in the Savelugu and Sagnarigu municipalities.
2. To compare the net benefits of using the ZECC storage technology with the net benefits of the traditional method of storage in the study area.
3. To examine factors influencing tomato farmers' and traders' adoption of the ZECC storage technology in the study area.
4. To identify and rank the constraints faced by the farmers and traders in using the ZECC technology in the study area.

1.4 Relevance of the Study

Having had ample literature on high rates of postharvest losses in tomato, it would be relevant to conduct studies that would suggest policy implications on how to improve on tomato storage and assess the overall financial viability of the tomato storage in Ghana. Although studies have been conducted on the economics of the ZECC storage technology elsewhere, the financial viability and factors that would influence its adoption has not been done in Ghana.

This study, therefore, seeks to create awareness on costs and benefits of using the ZECC storage technology in the Northern Region of Ghana, and provide stakeholders with relevant information on whether to invest in the technology or not. The findings in this study would also be a guide to facilitate future technological interventions by government, NGOs, and other stakeholders in making smallholder agriculture more efficient and attractive.

Also, this study would be of great significance since it would be added to existing literature and those in academia for future research. Finally, it will be of relevance to government in policy formulations, especially on the aspect of government investments and spending in tomato storage.

1.5 Organization of the Study

This study is organized into five chapters. Chapter One gives the background of the study with emphasis on the specific problems leading to the study. Chapter Two presents review of literature related to the study. Chapter Three provides the methodology for the study, including methods employed to analyse the set objectives, description of the study area, and data collection. Chapter Four presents the empirical results with discussion. Chapter Five, is the final chapter which presents the summary of the study, conclusions and recommendations based on the findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents review of relevant literature on the study. It highlights the characteristics of tomato, tomato production and marketing, the benefits of tomatoes storage systems, viability of the ZECC storage together with other storage technologies, types of storage and its process for usage, examination of the determinants of farmers' and traders' decision to adopt a storage technology, and other studies on adoption in relation to agricultural technology usage. And finally, literature on the various constraints farmers and traders face in adopting storage technologies as a whole.

2.2 Characteristics of Tomato

Tomato (*Lycopersicum esculentum Mill*) belongs to the Solanaceae family, which also includes other well-known species such as potato, tobacco, pepper and eggplant. Tomato has its origin in the South American Andes (Van, Goffau, Van Lidt de Jeude, & Naika, 2005). As per Anang *et a*l., (2013), the extremely different and extensive Solanaceae family is accepted to comprise 96 genera and more than 2,800 species conveyed in three sub-families: Solanoideae (in which Solanum has a place), Cestroideae, and Solanineae. According to Tambo & Gbemu, (2010), tomato is scientifically known to be a fruit but in trade is it categorised among vegetables.

Tomato is known to be a moderately brief span crop and gives a high return; it is monetarily profitable. It needs a moderately cool, dry atmosphere for high returns and better quality (Arah, Kumah, Anku & Amaglo, 2015). However, it can adjust to an extensive variety of climatic conditions of varied temperatures. In the Tropics, tomato is severely constrained by insects and mite pests (Ntow, Gijzen, Kelderman & Drechsel, 2006). Tomatoes are perishables which could decay easily if not properly handled and these affect their taste, flavour and nutritional value (Van *et al.*, 2005).

Tomato is one of the important crops recently cultivated in both rainy and dry seasons in Northern Ghana and Southern Volta (Ntow *et a*l., 2006). It provides important nutrients to food consumed at the household level, and many Ghanaian meals have tomatoes as an ingredient (Tambo & Gbemu, 2010). The high rainfall and humidity in Ghana breed pests and diseases, which adversely affect tomato production as reported by Anang, Zulkarnain and Yusif (2013). When tomato is harvested, environmental conditions considered as latent energy is removed from the canopy through evapo-transpiration mechanism, and make the tomato become more vulnerable to direct solar radiation. This is a major problem when tomato is transported in vehicles that are not climate controlled (FAO, 2003).

The features of tomato that are most desirable and appreciated by consumers are with its texture (firmness), size, shape, and colour. A variety of quality attributes of fresh produce can be considered in terms of colour as studied by Hossain, Strezov, Chan, & Nelson, (2010). Firmness is a widely accepted indicator of quality which can be measured easily and which has direct economic consequences. In addition, firmness is highly sensitive to external environmental conditions such as temperature and relative humidity.

Tomato is rich in folate, phytonutrients, carotenoids, lycopene, gamma-carotene and photogene, and in addition a few minor carotenoids (Anang *et al*., 2013). It is also rich in minerals, vitamins, fundamental amino acids, sugars and dietary filaments. Tomato contains vitamins B and C, iron and phosphorus. The crop is easily prepared into purees, juice, ketchup, and other forms which are used in different meals.

2.3 Tomato Production and Marketing in Ghana

Production

Tomato production plays an essential role in the economic activities in Ghana, especially in the Northern, Upper East and around southern Volta regions of Ghana (Gould, 2013). Major production areas includes Akumadan and the Wenchi districts. Commercial production, according to Norman (1992), is centered on Mankessim, Swedru, Agogo, Nsawam, Amasaman, Sege and Dodowa. Tomato production in Ghana is intensive, even though the methods of production are relatively old. The soil is usually prepared by crating hoes. The plants are grown in raised beds where watering is done by hand. The plants are grown in mounds, and seedlings are grown in nursery beds and transplanted to the field. In the field, the plants are staked and usually pruned to single stem.

The plants are uncertain, so flowering and fruit set occur over a considerable period of time. The commonly produced varieties are Roma, Pectomech, Burkina and Power (Khor & Hormeku 2006). According to Robinson & Kolavalli (2010), Ghana’s tomato sector has been unsuccessful in attaining its potential in terms of yields comparable to other countries, in terms of the ability to sustain processing plants, and in terms of improving the livelihoods of households involved in tomato production and the tomato commodity chain.

With different government interventions such as the establishment of tomato processing factories, the favourable quality and quantity of tomatoes for commercial agro-processing are not being produced (Norman, 1992). Many farmers still prefer to plant local varieties, typically with a high water content, many seeds, poor colour, and low brix. Land husbandry practices are often suboptimal. Average yields remain low, typically under ten tons per hectare (Robinson & Kolavalli, 2010).

Because of production seasonality, high perishability, poor market access, and competition from imports, some farmers are unable to sell their tomatoes, which are left to rot in their fields. Yet other farmers in Ghana have achieved higher tomato yields, production is profitable, and many farmers in Ghana continue to choose to grow tomatoes over other crops (Yeboah 2011). One of the key issues for tomato farmers in Ghana is high per-unit input cost. The cost of production and the returns attained after sales of the tomatoes mostly results in low income.

When farm gate prices are low and variable, as is mostly the case for rained farmers who plant according to the rains. These farmers are used to harvesting their produce at a similar time, which in turn reduce the per unit input costs. Further, for tomato processing to be competitive in Ghana, average per unit production cost needs to be considerably lower so that farmers can sell their tomatoes profitably at the low but guaranteed prices offered by the processors (Aidoo *et al*., 2014).

Marketing of Tomatoes

Tomato is one of the commonly demanding vegetables in Ghana. The in-take estimates from the 2012-2013 Ghana Living Standards Survey (GLSS) show that households spend about 12.8 % of total food expenditure on vegetables, of which the highest was tomatoes, an expenditure of (35.2 %). In spite of tomatoes demand and its necessity in the country, the demand for it is largely supplied by imports. Most especially from Burkina Faso. Ghanaian farmers are mostly unable to meet the productivity levels needed for the tomato to compete in the regional market, which according to the traders it is a mere perception or a myth.

The ability to bargain on a fair price mostly depends on whether a farmer will choose to produce the crop in the next season or whether the farmer will make investments to increase his or her income (Harriss, 1979). Trader decision to continue buying and selling tomatoes is equally based on these pricing effects. In Ghana, most of the vegetables marketed are affected by the associations of traders in a particular market. These associations are largely made up of wholesalers and retailers. These wholesalers and retailers are also controlled by female leaders called 'Queen Mothers' or 'Market Queens' (Robinson & Kolavalli 2010).

Peppenelen (2005) reported that these market based associations have the monopoly-like power in the vegetable sector in Ghana, especially when it comes to tomato marketing. These associations restrict mostly, the vegetable supply in the market system. First, in some markets, the wholesalers and retailers are forced to be registered members of the market before they can sell out their tomatoes. Traders who fail to do so are either not allowed selling in those markets or buying from the registered wholesaler. Secondly, because these associations have the power to control the market; they determine the quantity of supplies that enters the market. This is done by limiting the total number of trucks that comes to their market to offload the tomatoes (Robinson & Kolavalli 2010). Due to these reasons, farmers are not allowed to have access to this market when they harvest.

Tomato traders mostly travel to vegetable farms to purchase their produce. They mostly bargain with the farmers on the quantity and price at which they wish to buy the tomatoes and other vegetables available. Upon reaching a reasonable price, the farmers give the traders the produce. Even in some cases of the tomatoes in the major production areas, the traders harvest the tomatoes themselves, or hire labourers to do the harvesting. The major problem with this system of marketing vegetables is that, farmers are unable to have the bargaining right. The perishable nature of vegetables subjects the produce to early deterioration: and when sales are delayed, results in rotting and loss to the farmer or producer. This makes about 60% of the farmers' sales at the farm gate stage (Robinson *et al*., 2012).

The farm gate sales involves two types of buyers; thus, local buyers who sell to nearby markets, and traders or middlemen who buy and transport the produce to major markets at the capital cities. Farmers who sell their tomatoes themselves mostly are registered members of that particular market (Harriss, 1979). Recently, it was reported by Robinson & Kolavalli (2010) that, educated farmers now sell their tomatoes to one known buyer per season. This helps the farmers increase their profit and reduces the losses they were making previously. It is quite interesting to know that, most of the farmers who sell at farm gate received higher prices on average than farmers who sell their produce in the market. Although this may not be economically sound, it is the situation involved in the marketing of tomatoes in Ghana. Tomato prices averaged almost GHS 80 per crate if farm sales took place as opposed to off-farm. The production of tomatoes in the Upper East overlaps peak production in Burkina Faso. Ghanaian traders, who control access to important markets, prefer to buy Burkina Faso tomatoes (Robinson *et al*., 2012).

Trader's claim that the Burkina Faso tomatoes are of better quality than those from the Upper East, especially because they last longer and travel better, reducing the risk of loss to wholesalers. The association of tomato traders who import from Burkina Faso also claimed that locally produced tomatoes no longer stay on the same day as the tomatoes they import (Yeboah, 2011). In a survey done by Robinson *et al*. (2012), they found that tomato farmers do not store their crops for long. Especially tomato, irrespective of where ever their farms may be located, implying that most farmers would prefer to sell out their tomatoes instead of processing them to be sold later or storing them to meet the lean season where prices of tomatoes are higher.

2.4 Tomato Storage Systems

There are several storage systems for preserving fruits and vegetables particularly fresh tomatoes. Some of the systems have been highlighted and discussed as follows:

Refrigeration:

Fresh tomatoes purchased from a retail outlet or at a farm gate, usually ripe can best be eaten within 2 to 3 days if stored under room temperature. Within these days, the quality of the tomatoes is retained and hardly deteriorates (Parnell, Harris, & Suslow 2005). However, the unripe tomatoes can be held from a retail outlet for quite a longer time as compared to the ripe tomatoes. Refrigeration is not generally prescribed for freshly harvested tomatoes as it can cause season misfortune and also result in reduction of the tomato during sales. Softening of "simply ready" tomatoes can be postponed by holding them for a brief time frame in refrigerated capacity. Flavour misfortune will be insignificant if icy stockpiling keeps going under three days.

In the event that fresh tomatoes have to be refrigerated, they must be in the crisper area in their plastic clamshell compartment (if that is the means by which they were pack-matured in the store). A paper sack or a plastic sack should be used with a couple of openings, to help diminish water misfortune. It is best to expel the tomato from the fridge one hour before eating to enable it recovers a portion of its unique flavour.

Freezing tomatoes:

According to Parnell *et al*., (2004), tomatoes might be solidified to save life expectancy for a little while. In the process of freezing the tomatoes, they should be whitened before solidifying. Once solidified, the tomatoes are exchanged from the treat sheets into cooler packs or different compartments and sealed firmly. To utilize the solidified tomatoes, it is expelled from the cooler almost immediately or late. Frozen tomatoes can be used by peeling, and simply running a solidified tomato under warm water in the kitchen sink. The tomato skin slips off effortlessly. On the other hand, processing the tomato into other forms like blending or chopping into smaller pieces can be done and the freezing system can be applied after the processing.

Canning tomatoes:

Tomato canning is done by selecting healthy matured tomatoes; while sorting all spoilt and overly ripped tomato. The selected tomatoes are then washed in clean water and boiled. Boiling is prolonged enough to ensure that the tomato skin is cracked. They are then transferred into cold water for the skin to come off easily, after which the boiled tomato is stored in a sealed container (Parnell *et al*., 2004).

Drying tomatoes:

Drying tomatoes may be in the form of dehydration, oven drying or microwave drying. Dehydration drying reduces dampness of tomatoes to prolong their time of perishability. The amount of time it takes to dry tomatoes to some extent depends on the tomato assortment, the dampness amid the drying procedure, the thickness of the tomato cuts or pieces, and the proficiency of the dehydrator (Parnell *et al*., 2004).

Oven drying of tomatoes is possible, but because tomatoes takes a longer time to dry well, it is not advised most of the time. The method of drying sometime makes the kitchen hot. The heat formed during the drying sometimes can cause the skin of the person drying to burn. Where microwave drying is done, it needs enough attention, and frequently opening the microwave door to allow moisture to escape. Microwave-dried tomatoes do not dry evenly, and can easily scorch or burn.

Clay pot storage:

This storage is done by inserting a constructed clay pot in another clay pot (pot-in-pot). In India, this type of storage is also referred to as Zeer. The space between the two pots is filled with sand and wetted some few minutes before the harvested tomatoes or left over tomato are stored. Pal *et al.,* 2004) reported that the wet surface around the pot makes the inside of the inner pot cool. The tomato is then sorted, cleaned and placed in the pot.

Ash storage:

Ash storage is done by burning dry banana leaves with other crop debris. The ashes are then collected, seized and placed in boxes. Matured tomatoes are kept in the ash for 5 to 6 days and sold out or used (Anaisk, 2017). Although this storage does not store for long, the quality of the tomato remains unchanged.

2.4.5 Zero-energy storage technology

According to Sturm *et al.,* (2012), a zero energy cool chamber does not need any type of energy to run. The structure which is constructed with locally accessible materials, depends on the evaporative cooling system. Materials required include blocks, stream bed sand, bamboo and water. Two parallel block dividers are built into a type of rectangle over the ground, and the space between the dividers filled with sand. The structure is illustrated in Figure 2.1.

A standard scale unit of about 165 cm by 115 cm floor is built, with a cavity of 67.5 cm high, leaving a space of about 7.5cm. The sand-filled space is soaked with water, and a shed made of bamboo and straws of grass is constructed over the chamber. Evaporative cooling happens when air, escapes from a wet place (Pal & Roy, 1988). This cools the sand-bed of the cool chamber. As water dissipates from the bed, it causes a cool impact and speedier rates of dissipation prompt more noteworthy coolness.

2.5 Tomato behaviour in the ZECC and other storage technologies

In a test on how tomato behaves in the ZECC storage technology, Islam *et al.*, (2013) reported that harvested tomato at maturity has a shelf-life of only about seven (7) days at ambient temperature. Storing tomato inside the ZECC could extend storage life up to fifteen (15) days by reducing the rate of its degradation due to reduced weight loss. Loss in weight (PLW) was faster for fruits held at ambient temperature. Weight loss during storage at ambient temperature was 5.4%, but using ZECC storage over the same period showed a weight loss of 2.6%.

Figure 2.1: Structure of the ZECC

Source: Anais (2017)

The effect of hot water treatment (60℃ for 3 minutes) on quality of tomatoes was found to increase storage life up to twenty-nine (29) days. It reduced weight loss and decay, inhibited colour development and maintained firmness of tomatoes. Hot water treatment slightly reduced the mould growth of tomatoes stored inside ZECC. According to Islam, *et al*. (2013), the ZECC storage technology is considered a very low cost technology structure, with the following advantages during its usage:

1. The nutritive value of fruits and vegetables stored under the ZECC is always retained and is very environmentally friendly.
2. The ZECC does not only reduce the air temperature around the produce, but also raises the moisture content of the air. This helps to prevent the drying out of the produce and, therefore, extends its shelf life.
3. It is inexpensive to install, and can be easily made, operated and maintained.
4. It is basically constructed using unskilled labour, without the application of machines or electricity, and
5. It is economical and can store ripe fruits and vegetables for 3 to 5 days without any significant loss (Pal & Roy, 1988).

Although the ZECC has several advantages, it also has a number of disadvantages. Notable among them are the following:

1. Evaporative cooling system requires a constant water supply to wet the pads, and therefore, needs to be watered daily (Ambuko, Wanjiru, Chemining'wa, Owino, & Mwachoni, 2017).

2. Enough space is required outside the home; therefore in locations where there is limited space, it makes the effective use of the ZECC difficult.

3. ZECC requires a lot of water, and therefore, when water which is high in minerals is used, it leaves mineral deposits on the pads (bricks) and damage the interior of the cooler.
4. A high humidity situation reduces the cooling ability of the chamber (Ambuko *et al*., 2017).
5. Evaporative cooling adds moisture; and in dry climates, dryness may not improve thermal comfort at higher temperatures.

2.6 Studies on Viability of the ZECC and Other Storage Technologies

The ZECC and other storage technologies for storing fruits and vegetables over the past decade have been of keen importance (Singh *et al*., 2007). Some studies have been conducted to ascertain the profitability of some of these storage technologies. Among others, Pal & Roy (1988) in assessing the economics of the ZECC and the Clay Pot storage technologies in India used the Cost-Benefit technique in their analysis and reported positive Net Present Values (NPVs) for both selected storage technologies. This suggested that storage under these storage technologies would be financially viable. They recommended improvement on these structures and the promotion of education to ensure sustainability and profitability of these technologies.

Equally, in Sierra Leone, Jenny, Anakus, & Nwimana (2013) confirmed a positive Net Present Value for the usage of the Ash storage technology (a new technology introduced) and the traditional storage system for tomato. Although their analysis of the viability had a limitation, the Net Present Value and the Benefit-Cost Ratio of the Ash storage were greater than those of the alternative traditional storage system. Based on these results, they concluded that investment in the Ash storage was more viable and should be adopted by the native farmers in the study area.

Drew and Rhee (1980) on the other hand used the profit and loss analysis in determining the cost and benefit of using freezer and other energy demanding storage and revealed that energy demanding forms of storage are cost effective.

2.7 Factors that Influence Adoption of Agricultural Technologies

Technology adoption has not achieved a standard definition by many researchers. Most current amongst the new definitions have been that of Loevinsohn, Sumberg, and Diagne (2012). They defined technology adoption as the processing and acquiring of a systematic ease device which results in an easier and accurate work done as compared to the non-existence of that device. As per these writers, the technology adopted is mostly new in the areas where they have been introduced , and hence, how the technology is used, or about to be used at a specific place depends on the culture and level of knowledge of the people in that location. According to Lavison (2013), adopting technologies are the learning or data that makes a few assignments to be finished more effectively. This helps the users of the technology to work less than they would have without that technology. Thus it enables spare time and work (Bonabana-Wabbi 2002).

Quite a lot of literature has been reviewed when it comes to technology adoption and the determinants of its usage. According to Loevinsohn *et al.* (2012), the decisions taken when a person wants to use a new technology is dependent on the nature of the technology itself and situations around the surroundings (place) of that technology. A comprehension of the components affecting this decision relies both on the financial analysis and the dissemination of such technology (Pavao, 2005).

Generally, financial investigation on innovation appropriateness clarifies selection conduct in connection with individual attributes and enrichments, defective data, hazards, vulnerability, institutional requirements, input accessibility, and framework (Feder *et al*., 1985; Koppel 1994; Foster & Rosenzweig 1996; Kohli & Singh, 1997; Rogers, 2003 and Uaiene, 2009). A few examinations group these variables into various classifications. For instance Akudugu *et al*., (2012) assembled the determinants of technology adoption into three classes: financial, social and institutional components. Lavison (2013) extensively arranged the components that impact selection of advances into social, economic and physical classifications, while McNamara, Wetzstein and Douce (1991) sorted the variables into users attributes institutional qualities and administrative structure.

Technology factors:

The nature of a technology introduced can determine whether or not people will adopt it or not. The extent to which a potential adopter would try a technology depends on the results observed or seen by previous users of that technology (Arah *et al*., 2016). In considering the determinants of a new technology in Western Kenya, farmers who saw the benefit of using the Imazapyr-Resistant maize (IRM) adopted it earlier. When they discovered that, the use of the newly introduced maize crop resulted in high yield, reduces the level of damage, and had a positive venture; their adoption rate increased (Mignouna, Manyong, Rusike, Mutabazi, and Senkondo, 2011).

A comparative outcome was accounted for by Doss (2003) when contemplating on the understanding of farmers' level when it comes to technology adoption in the Eastern Africa reported that, the perception towards the adoption of a technology was based on the fact that, it was appropriate to use and the conditions around its adoption was based on the fact that, an NGO was given subsidies to the adopters.

Institutional factors:

Having a social gathering improves social capital, permitting trust, thought and data trade (Mignouna *et al*., 2011). As indicated by Mwangi and Kariuki (2015), farmers and traders belonging to a social gathering gain from each other and the advantages of the use of another innovation. Uaiene *et al*.,(2009) proposes that interpersonal organization impacts are essential for singular choices, and that, in the specific setting of agrarian developments, ranchers share data and gain from each other centering on the impact of group based association in selection of the innovated technology in Uganda, Katungi and Akankwasa (2010) found that ranchers (managers of larger farms) who partook more in group-based associations were probably going to show more interest in trying to know more about the innovation, consequently raising their probability to receive the advancements. Numerous analysts have revealed a positive impact of social gathering on technology adoption or an innovation selection.

Foster and Rosenzweig (1995) when considering reception of Green Revolution innovations in India found that learning externalities inside informal communities expanded the productivity of selection, yet additionally agriculturists gave off an impression of being free-riding on their neighbours' experimentation with the new innovation. Bandiera and Rasul (2002) in Hogset (2005) revealed that learning externalities produce inverse impacts to such an extent that, the more other individuals take part in experimentation with another innovation, the more useful it is to participate, and the more helpful it is to free-ride on the experimentation of others. In addition to factors that aid adoption of new innovations, access to extension service and access to credit were also reviewed.

Access to extension services:

Agriculturists are educated on the viable utilization and advantages of new innovations through extension officers. Extension officers serve as specialists between the trend-setters of the innovation and clients of a given innovation. This lessens exchange costs incurred when passing on the new innovation to an expansive heterogeneous populace of ranchers (Genius *et al*., 2010). Extension specialists, more often than not, target particular agriculturists who are perceived as educators, as the major source of influence to farmers in terms of innovation adoption (Genius *et a*l., 2010).

There have been numerous creators who have reported positive relationship between an innovation selection and technology adoption. An example of this relationship is an adoption study on the maize resistant crop by Mignouna *et al*. (2011); factors influencing the decision to select the innovation reception among Nepalese (Karki & Bauer, 2004; Uaiene *et al.*, 2009); adoption of enhanced maize and land administration in Uganda by Sserunkuuma (2005); and selection of current farming advances in Ghana by Akudugu *et al*., (2012).

Access to credit:

Having access to credit mostly influence an individual to either adopt the technology or otherwise, (Mohamed & Temu, 2008). It is observed that, having access to credit advances the reception of hazardous innovations through the boosting of household's risk bearing capacity (Simtowe & Zeller, 2006). Access to credit has also been observed to be sexually oriented in a few nations. In families where females are the head or bread winner, they are oppressed by acknowledged foundations, resulting in not been able to fund yield-raising innovations, and prompting low selection rates (Muzari *et al*., 2013). Despite this report in other countries, the vice is said of most female-heads in other countries (Muzari *et al*., 2013). In a recent report by FOASTAT (2014) there has been a program that offers free advances to the young women in Kenya by their legislation, known as the UWEZO support. The support program is empowering these young people and enabling this to acquire the new horticultural innovations introduced, which in return boosting the development of their financial instability.

Household factors:

Most adoption studies revealed that, assessing human capital through the farmer’s age, sex, level of education, and household size (Atibioke *et al*., 2012; Mignouna *et al*, 2011; Keelan *et al*., 2014; Arah *et al*., 2016) is essential when it comes to technology adoption and innovation selections.

Age:

Age is usually expected to have influence on adoption of an agricultural technology. There is that believe that, matured and older farmers have the experience and skills needed unlike the young and immature youth growing up. The assumption is that, firstly they have the required assets to adopt when it comes to financial assets. Secondly older farmers have gained enough skills and experience and are in the best position than younger farmers (Kariyasa & Dewi., 2011 and Mignouna *et al.*, 2011).

Also, most adoption studies report that age most have a negative relationship when it comes to adoption. Mauceri *et al*., (2005) & Adesina and Zinnah (1993) explains that, this results is negative because, when older farmers are aging, they see adoption of a particular technology to have a high risk. What they might have achieved at that level is what they live on till they pass away. This deters them from adopting and investing in a newly introduced technology. But unlike younger farmers, they are typically the less risk-averse. They are eager to make a lot of money, and explore new technologies. Especially in cases where the technology has been proven to ease the effort toward their work done, and assures them of higher income. This study was backed by a research done by Alexander & Van in 2005. They found that, younger farmers had a positive relationship on adopting of genetically modified maize when it was introduced, as compared to older farmers.

Gender:

Gender issues in agricultural technology adoption have been studied regarding the different roles men and women play in technology adoption (Bonabana-Wabbi, 2002). The impact of sex on technology adoption, as detailed by Arah *et al*., (2016) had discovered no noteworthy relationship amongst sexual orientation and likelihood to receive enhanced maize in Ghana.

They inferred that, technology appropriation choices depend principally on access to assets, instead of on sex; and if selection of enhanced maize relies upon access to land, work, or different assets, and if in a specific setting males have a tendency to have preferable access to these assets over females, at that point in that setting the advancements will not profit people similarly. In any case, Atibioke *et al*., (2012) found that male ranchers swing to embrace new agrarian innovations more than female agriculturists.

Furthermore, sexual orientation may affect a few innovations. Sex influences innovation selection since the leader of the family unit is the essential chief and male have full access to and control over creation assets than female due to socio-social qualities and standards (Mesfin, 2005; Omonona *et al*., 2006; Mignouna *et al*., 2011). For example, an examination by Obisesan (2014) on appropriation of innovation found that, sexual orientation impacted selection of enhanced cassava creation in Nigeria. His outcome vanquished with that of Lavison (2013) which showed that male ranchers will probably embrace natural manure not at all like their female partners. Family unit estimate is essentially utilized as a measure of work accessibility. It decides selection process in that, a bigger family has the ability to unwind the work limitations required amid presentation of new innovation (Mignouna *et al.*, 2011; Bonabana-Wabbi 2002).

Education:

Education of the farmers and traders has been assumed to have a positive influence on their decision to adopt new technologies. Educational level of a farmer or trader increases his ability to obtain process and use information relevant to adoption of a new technology (Mignouna *et al*., 2011; Lavison 2013; Namara *et al*., 2013). For instance a study by

Okunlola *et al.,* (2011) on adoption of new technologies by fish farmers on organic fertilizers found out that the level of education had a positive impact and significant influence on adoption of the technology. This is because higher education influences respondents' attitudes and thoughts; it makes them more open, rational and able to analyse the benefits of the new technologies introduced (Waller *et al*., 1998). This eases the introduction of a new technology which ultimately affects the adoption process (Adebiyi & Okunlola, 2010).

Other studies that have reported a positive relationship between education and adoption as cited by Uematsu and Mishra (2010) include: Goodwin and Schroeder (1994) on forward pricing methods, Huffman and Mercier (1991); and Putler and Zilberman (1988) on adoption of microcomputers in agriculture, Mishra and Park (2005); and Mishra *et al*., (2009) on use of internet, Rahm and Huffman (1984) on reduced tillage, Roberts *et al*. (2004) on precision farming and Traore, *et al*. (1998) on an on-farm adoption of conservation tillage. On the other hand, some authors have reported insignificant or negative effects of education on the rate of technology adoption (Grieshop *et al*., 1988; Khanna, 2001; Banerjee, *et al*., 2008; Samiee *et al*., 2009). Studying the effect of education on technology adoption, Uematsu and Mishra (2010) reported a negative influence of formal education towards adopting genetically modified crops. The fore going empirical evidence have shown mixed results on the influence of education and adoption of new technology.

2.8 Constraints Faced in Adopting Storage Technology

Constraints to tomato production and storage have been empirically presented as problems associated with land rents, water charges and costs of tractor services, pesticides, seed and fertilizer (Clottey, Karbo & Gyasi, 2009). According to Clottey *et al*. (2009), constraints tomato farmers face were: inadequate number of tractors and land for expansion, no places to locate nurseries, poor seed quality, high incidence of diseases, no storage facilities, difficulties in accessing credit, and no ready markets. All these constraints were summed up as lack of capital to invest in tomato production and storage. Aside the biological and environmental factors that contribute to post-harvest losses, Kader (2004) reported that some socioeconomic factors such as marketing systems and transport systems can be attributed to the incidence of post-harvest losses.

Firstly, the challenge of inadequate marketing systems exists in many developing countries like Ghana where producers of fresh vegetables and fruits produce large quantities of their commodities which results in post-harvest losses. However, there is also no dependable and fast means of getting such commodities to the consumer hence losses become extensive. These come about as a result of lack of communication among the actors. Kader (2004), therefore, suggested marketing cooperatives should be encouraged among producers of major commodities that are exportable.

Also, alternative distribution systems such as direct selling to the consumer (road side sales, produce market in cities and local farmer's market) should be encouraged. This is evident and is usually practiced in Ghana especially in production areas. An inadequate transport facility to properly transport the horticultural crops to the markets is also another constraint. Even if there are some vehicles, they are mostly not in good conditions to cart produce from the production sites. Finally, local farmers and traders may not be able to afford their own transport vehicles hence the produce tends to keep long before it reaches its destination.

Furthermore, Kader (2004) included lack of post-harvest information as another socioeconomic factor leading to losses in horticultural crops. He indicated that good post-harvest handling activities are not properly disseminated to the farmers and traders consequently, information on how to handle crops are limited to those who perform or are directly involved in harvesting, packaging, transporting, and marketing of the produce. Hence he suggested that farmers and traders need the requisite knowledge about postharvest handling practices to enhance reduction or minimize losses. Diiro, (2013) indicated that, the absence of farm storage facilities and proper pack house or packing station results in the perishability of the produce hence it is sold immediately after harvesting without primary processing or adequate packaging. Tomato yields are influenced by seed variety.

However, tomato cultivators in Ghana are compelled by the nonattendance of national seed procedure that furnishes agriculturists with a dependable wellspring of fitting seeds and specialized help (Robinson & Kolavalli, 2010). Consequently, Ouma *et al.,* 2002) recommended that there was the need to concoct assortments that could withstand the transportation harms or enhance the dealing with capacity of assortments developed. A study by MoFA (2012) additionally showed that absence of store rooms, inconsistent transport and absence of information on post-gather procedures were not requirements that tomato farmers and traders in Ghana were confronted with. Adarkwa (2011) detailed that uncalled for collect and post-reap rehearsals bring about misfortunes because of deterioration of the item before achieving the market and misfortunes of value traits, such as, appearance, solidness, taste and nourishing quality.

Adu-Dapaah and Oppong-Konadu (2002) concentrated on cultivation practices and creation imperatives. As indicated in their paper, the elements in charge of low yields of tomato incorporate poor adjustment of enhanced assortments, wasteful seed conveyance framework, and poor administration of water system water frameworks, mistaken planning of the use of information sources and absence of powerful sensitivity analysis and malady control instruments. The paper presumed that the components that cut off the size of tomato generation were high cost of creation and absence of access to credit.

Issahaku (2012), however, focused on constraints across the whole tomato industry and that includes several actors in the production and marketing chain. These include farmers, wholesalers, retailers and processors. Hence this survey analysed the challenges confronting the whole industry by seeking views from not only some but all the stakeholders involved. The major problems that confronted the tomato value chain were found to be low prices, price volatility, lack of access to credit, poor quality of tomatoes, inadequate storage and warehousing facilities, inadequate transportation facilities, dispersed nature of source of supply, high interest rate and lack of adequate information.

Low price was ranked as the most worrying constraint of farmers while poor quality of tomatoes produced in Ghana was ranked as the most pressing constraint of wholesalers and retailers. Aidoo *et al.*(2014) in a survey reported and emphasized that there were other things that contributed to post–harvest losses and these included time of harvest, type of variety grown and technology adopted in handling the produce. These constraints were ranked least whiles lack of market avenues, unreliable transport and longer distance to market were considered the three most critical constraints causing secondary losses.

2.9 Summary of Literature Reviewed

The above reviewed literature helps understand the gaps in the study. Reviews on other tomato storage technologies provide a clear understanding on why the ZECC should be adopted due to its advantage over the others. It identifies economic, institutional, technological and family characteristics as the primary factors influencing the choice of the ZECC and highlights the fact that the studies cut across countries and regions around the globe and that it is applicable everywhere.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the study area with brief discussions on data collection method. This chapter highlights information on types and sources of data, the appropriate sampling technology, sample size, and the instrument used for the data collection. This chapter further presents the conceptual and theoretical frameworks used for the study. This chapter indicates the method of analysis used to achieve the various objectives set for the study.

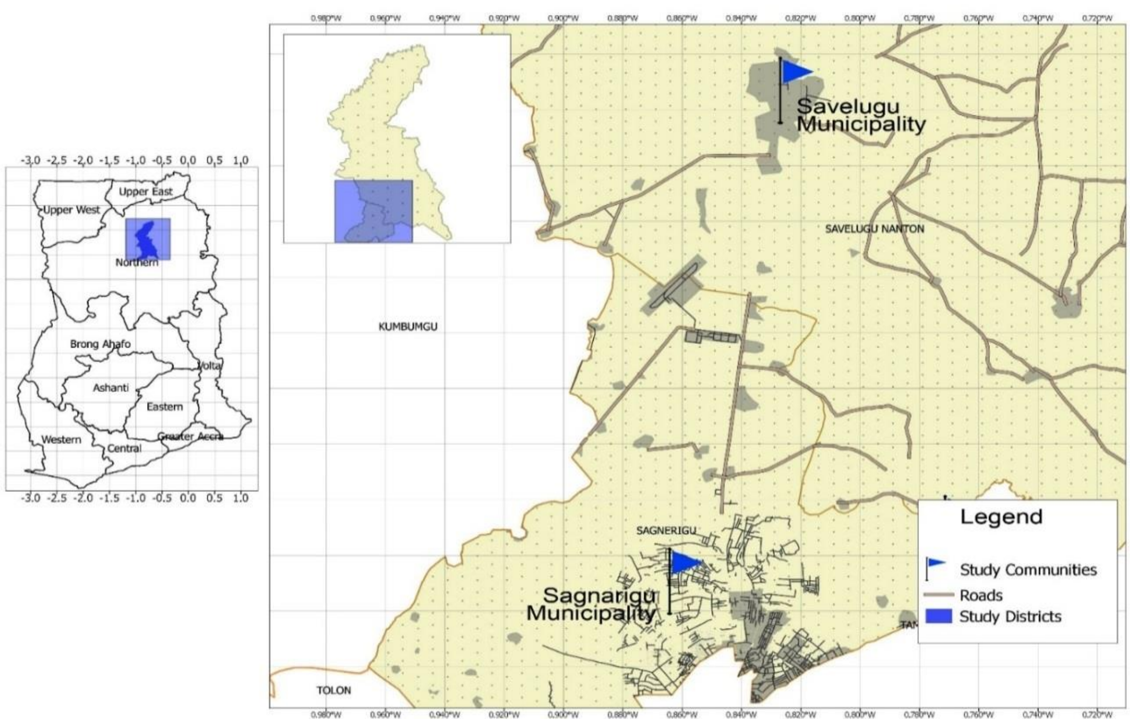
3.2 Research Design

This study employed an exploratory research design, a mixed method approach which considered both qualitative and quantitative data. This design was deemed appropriate for this study since it provides understanding and empirical evidence on the factors that influence the adoption of tomato storage technology among farmers and traders in the Northern Region of Ghana.

3.3 Study Area

The study area is located at the Savelugu and Sagnarigu municipalities. The Savelugu municipality is located at the northern part of the Northern Region of Ghana. It shares boundaries with West Mamprusi to the North, Karaga to the East, Kumbungu to the West and Tamale Metropolitan Assembly to the South. The altitude of the municipalities ranges between 400 and 800 feet above sea level. The population of the municipality according to 2010 population and housing census stands at 139,283 with 67,531 males and 71,752 females. The municipality is located in longitude and latitude 9°24′N and 0°28′W, respectively. Also, the Sagnarigu municipality lies between latitudes 9º16' and 9º 34' North and longitudes 0º 36' and 0º 57' West. The municipality covers a total land size of 200.4km² and shares boundaries with the Savelugu municipal to the north, Tamale metropolis to the south and east, Tolon District to the west and Kumbungu District to the north-west. The population of the municipality according to 2010 population and housing census stands at 148,099 with 74,886 males and 73,213 females (GSS, 2014).

Figure 3. 1: Map of Savelugu and Sagnarigu Municipalities in the Northern Region of Ghana

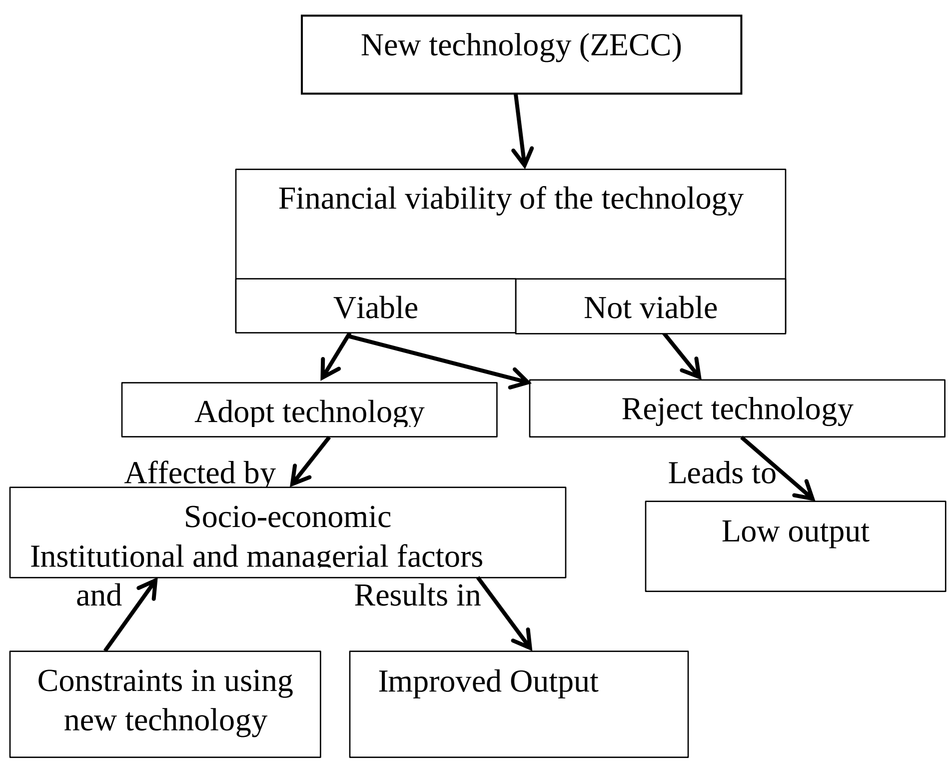


Source: University of Ghana, Geography Department (2018)

3.4 Conceptual Framework of the Study

This study conceptualizes the interrelationships among variables as illustrated by the framework in Figure 3.2. The smooth running and sustainability of all businesses requires enhanced output which results in profits (Baba, 2017). A new technology may either be financial viable or otherwise, and offers opportunities for adoption. Where the technology is viable and has been adopted, it results in an enhanced output subject to the influence of factors which may be socio-economic, institutional or managerial. Likely constraints in the use of new technology are also important to help the sustainability of the technology.

Figure 3.2 Conceptual Framework



Source: Author's Construction (2018)

3.5 Theoretical Framework

The theoretical framework underlying adoption is based on individual investment, behaviour and profit maximisation. A farmer or trader maximizes profit by producing, storing or distributing a quantity of goods that indicate the level of combination of inputs (technology adoption). Farmers and traders derive satisfaction from the utilization of inputs (example storage technologies) they use in storage or marketing to maximize output or profit margins. Assuming a farmer has access to a storage technology (an intermediate good), then the farmer's expected production output or profit margin, according to Greene (2012) is represented mathematically as shown in equation 3.1.

$$\boldsymbol{Q_i = q_i(Y_j, X_j, e_{ij})} \quad \textbf{(3.1)}$$

Where

Q_i	=	the Output/Profit level of farmer/ trader *i* by good/ input
Y_j	=	the household income for farmer/trader j
X_j	=	the vector of the observed characteristics of the farmer/trader and of the given choice of the farmer/ trader
e_{ij}	=	the unobserved error term of the indirect production (profit) function.

The farmer or trader will agree to adopt an input (tomato storage technology) if and only if the output (profit) derived from the new technology is greater than the profit derived from the traditional methods. That is, if

$$\boldsymbol{Q_i\left(Y_j - Y_i^*, X_j, e_{ij}\right) > Q_j(Y_j, X_j, e_{ij})} \quad \textbf{(3.2)}$$

Where

Y_i^* denotes the farmer's or trader's income (profit margin). The probability that the *jth* farmer or trader responds 'yes' is an indication that he or she has access to credit is given by:

$$\textbf{Pr (yes)} = \boldsymbol{Q_i\left(Y_j - Y_i^*, X_j, e_{ij}\right) > Q_{ij}(Y_j, X_j, e_{ij})} \qquad \textbf{(3.3)}$$

A common formulation of the profit maximization model is the additive profit model (Cameron and Trivedi, 2005). Thus the Additive Profit Model assumes that the storage (profit) function is additively separable into deterministic and stochastic preferences.

This is given as:

$$\boldsymbol{Q_{ij} = Q_i(Y_j, X_j) + e_{ij}} \qquad \textbf{(3.4)}$$

Hence, the probability statement that a respondent answers 'yes' to an adoption of ZECC technology is, therefore, illustrated as:

$$\textbf{P}_\textbf{r} \textbf{ (yes)} = \boldsymbol{Q_{ij}\left(Y_j - Y_i^*, X_j\right) + e_{ij} > Q_{ij}(Y_j, X_j) + e_{ij}} \qquad \textbf{(3.5)}$$

According to Greene (2012), Pr is hypothesized to be a function of household's socioeconomic characteristics such as age, sex, education, household size, access to credit, access to storage technologies, etc. These exogenous variables were employed to examine socioeconomic characteristics of tomato farmers and traders that will influence the intention to adopt new technologies.

The theory underlying the financial analysis is based on Cost-Benefit Analysis technique which used the discounted measures of project worth such as NPV and BCR. According to Gittinger (1982), Cost-Benefit Analysis shows the worth of an investment by comparing the costs involved with the benefits. This is used for financial analysis of projects in order to assess the financial viability of the project. Financial analysis was used because it takes into account both costs and benefits. The total cost involved in the storage of tomato is the sum of fixed or capital costs and recurrent or operating costs. These costs are inherently different both with respect to the cost structure itself and to the timing of accruals.

According to Gittinger (1982), the total costs are compared with the benefits to see whether the investment is financially justifiable. This is done taking into account the different times at which costs and benefits are realized over the life of the investment through the use of discounting which reduces all the future values to their present worth. The present worth of the cost is compared with that of the benefit in which the discounted measure of project worth such as Net Present Value (NPV), Benefit-Cost Ratio (BCR) at a given discount rate. The decision rule is that an investment is financially viable if NPV is greater than or equal to zero, and BCR is greater than or equal to one. For policy makers, sensitivity analysis is conducted to test the sensitivity to changes in assumptions about prices, delay in implementation, cost overrun and yield. That is, the NPV and BCR are tested to see whether the investment will be viable under these changes underlying the Cost-Benefit analysis.

3.6 Methods of Analysis

This part of the study illustrates the various methods employed in addressing the specific objectives of this study.

3.6.1 Determining the Level of Awareness and Usage of ZECC Technology

Descriptive statistics such as percentages and frequencies were used to determine the level of awareness of the ZECC storage technology among the tomato farmers and traders. A three point Likert scale was applied in the case of their various reasons for the usage of the ZECC and the traditional methods of storage. The scale was constructed as 1= disagree, 2 = indifferent, 3 = agree. The number of farmers and traders according to their reasons was determined, and the weighted mean index calculated to reflect their priority reasons for using the ZECC storage technology and the traditional method. The weighted mean index (WMI) is mathematically given by:

$$\frac{\text{Wi } x \text{ Fi}}{N} \qquad \textbf{(3.6)}$$

Where

Wi is the weight of the i^{th} reason

Fi is the response rate of the i^{th} reason; and

N is the total number of respondents

The decision rule for degree of agreement on the reasons for using the ZECC and TMS variables are:

1. A bench mark of 2.5 would be used.
2. Agree if weighted mean index is greater than or equal to 2.5($WMI \geq 2.5$)
3. Indifferent if weighted mean index is greater than 1.5 but less than 2.5 ($1.5<WMI<2.5$), and
4. Disagree if weighted mean index is less than or equal to 1.5 ($WMI \leq 1.5$)

This allowed for the calculation of general or overall reasons for using either of the two storage methods.

3.6.2 Comparing Net Benefits of ZECC Storage and the Traditional Method of Storage Technologies

Assumptions

Comparing net benefits requires the generation of cash flows for both technologies under the following assumptions:

The cash flow was generated over a period of fifteen (15) years; this is based on the fact that, the main capital item of the initial investment has a useful life of fifteen years. This number of years was assumed to have given enough room to make up for the cost and benefit from the investment (Kuwornu *et al.*, 2013). The ZECC facility has a 50-kilogram storage capacity with a floor space of about three (3) square-meters. Costs were entered in the year in which they were incurred and benefits as and when they were realized, using constant average prices (Gittinger, 1982). The residual value was computed as the proportion of the capital cost left at the end of the useful life of the project, including the salvage value**.** It is assumed that no repairs and maintenance was done in year one due to the fact that, the items were new and no repairs or maintenance would be needed. Notwithstanding, repairs and maintenance is assumed to increase by 5% in years 3 to 7, and remain constant in the subsequent year; because most of the items had been expected to be replaced at some point over the 15 years. Therefore, reducing the cost of repairs and maintenance.

Items were valued at constant prices to eliminate the influence of inflation. The cash flows were discounted at 21 percent discount rate, which represents the lending rate of rural banks in Ghana for agricultural investments at the time of the study. All other costs, except casual labour were assumed to be directly proportional to revenue. Operating cost was allocated a 5 percent contingency cost, which would be used should there be an adverse change in the prices of inputs.

'With' and 'Without' Project Cash Flow Analysis

The with' and 'without' project cash flow analysis was employed to ascertain whether the net benefits from the use of the ZECC storage technology is higher than the net benefits of the existing method of storage. Cash flows were generated for the ZECC storage technology and the TMS. Then the incremental cash flow was obtained as the difference between the two cash flows. Discounted measures of project worth such as the Benefit-Cost Ratio (BCR) and the Net Present Value (NPV) were used to determine the financial viability of each form of storage, and the incremental NVP for comparing the ZECC storage technology with the existing method. A positive incremental NPV indicates that the ZECC storage technology is more financially viable.

According to Gittinger (1982), the Benefit-Cost Ratio is defined as the value today of all benefits divided by the value today of all costs. The equation is given as:

$$BCR = \frac{\sum_{0}^{T} B_t}{\sum_{0}^{T} C_t} \quad \textbf{(3.7)}$$

Where

B_t = benefits in a time t

C_t = costs incurred in time t

The Net Present Value (NPV) is defined by Gittinger (1982) as the difference between the value today of all benefits and the value today of all costs. The equation is stated as:

$$NPV = \sum_{t=0}^{t=T} (B_t - C_t) \frac{1}{(1+r)^t} \qquad \textbf{(3.8)}$$

Where B_t and C_t are as earlier defined and r = discount rate.

The decision rule states that if NPV is greater than zero, then the project is said to be financially viable; hence it can be accepted.

Sensitivity Analysis

A sensitivity analysis was conducted using switching values. It takes into account the extent parameter's value would change for a project that is acceptable to become unacceptable, or a project that is unacceptable to become acceptable. For example, investors would like to have knowledge on how much cost would increase and/or how much benefit would reduce before the Net Present Value (NPV) of a project falls to zero. Switching values are determined by examining the Benefit-Cost Ratio (BCR) and Cost-Benefit Ratio (CBR) for changes in cost and benefits, respectively.

That is, BCR minus 1 gives the percentage by which costs would increase to make the project break-even, while 1 minus CBR gives the percentage by which benefits fall to make the project break-even.

An increase in cost beyond the break-even point or fall in benefit below the breakeven point will render the project unacceptable.

3.7 Examining the Factors that Influence Tomato Farmers' and Traders' Adoption of Storage Technology

To analyse the factors that statistically influence tomato farmers' and traders' decision to adopt a particular technology, the probit regression model was used. The method of estimation of the probit model was by maximum likelihood. The interpretation of probit results is based on marginal effects treated as probabilities. The marginal effect explains the slope of the probability curve relating one explanatory variable to a prob (y=1|x), holding all other variables constant.

The observable dependent variable is defined by:

$$y = \begin{cases} 1 \ \textit{Adopt technology} \ \ if \ \ y^* > 0 \\ 0 \ \textit{no adoption} \ \ if \ \ y^* \leq 0 \end{cases}$$

The Probit model Y follows the Bernoulli distribution with probability

$$\pi_i = prob(y = 1) = \Phi(X\beta) \tag{3.9}$$

Where π_i is the probability that tomato farmers and traders would either adopt the ZECC storage technology or remain as non-adopters. $X_i^{'}$ is the explanatory variables, β_i is the regression parameters to be estimated.

In the Probit model the functional distribution of the error term is very important to constrain the values of the latent variable into desirable properties of probability values of between 0 and 1. The Probit model assumes a cumulative distribution function of standard normal distribution represented by Φ .

$$\begin{aligned} prob(y=1) &= prob(y_i^* > 0) = prob(\beta X + e > 0) \\ &= prob(e > -\beta X) \\ &= prob(e < \beta X) \\ &= \Phi(\beta X) \end{aligned} \quad \textbf{(3.10)}$$

In the case of a normal distribution function, the model to estimate the probability of observing respondent's choice to adopting a technology can be represented as:

$$\Pr ob(y_i = 1/\mathrm{X}) = \Phi(\beta X) = \int_{-\infty}^{\beta X} \frac{1}{\sqrt{2\Pi}} \exp\left[\frac{-z^2}{2}\right] \partial z \quad \textbf{(3.11)}$$

Where

y_i is the Probability (dependent variable*)* that a respondent would chose adopt the ZECC technology or not, X is a vector of the explanatory variables, Z is the standard normal variable (Z ~N $(0, \delta^2)$) and β is a k by 1 vector of the coefficients estimated. The empirical probit model is specified as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots\ldots + \beta_n X_n + U_i \quad \textbf{(3.12)}$$

Variable Definition and Justification

The variables included in the model, with their units of measurement and a-priori expectations, are described in Table 3.1.

X_1: Gender

In the northern regions of Ghana, women have less access to land and other assets needed for investment, and most decisions in their homes are taken by either their husbands or fathers who often influence the way household resources are allocated.

Gender in this study is expected to have a positive influence on the adoption of the ZECC storage technology, given that males are assigned 1 and females 0.

Table 3.1: Variables and a Priori Expectation of the Probit Model

Variables	Description	Measurement	A-priori expectations
Gender	Gender of respondent	1 = male, 0 = female	+
Age	Age (in years)	Number	+
Household Size	Number of persons in household of respondent	Number of persons	+
Education	Years of education	Number of years	+
Marital status	Marital status	1 = married, 0 = otherwise	+/-
GBO	Membership of group-based organisation	1 = member, 0 = otherwise	+/-
Extension	Number of extension visits	Number	+
Location	Location of respondent	1 = Savelugu, 0 = Sagnarigu	+/-
Perceived Cost of ZECC	Perception of high cost of ZECC	1 = high, 0 = otherwise	+/-
Monthly Tomato income	Average monthly tomato income	Ghana cedis	+/-
Savings	Average income saved per month	Ghana cedis	+
Type of person aware	Type of person aware of the ZECC	1 = trader 0 = farmer	+/-
User of TMS	Traditional method of storage user	1 = yes 0 = no	+

Source: Author's construct (2018)

X_2: Age

It is also expected that, age would have a positive influence on the adoption of the ZECC storage technology up to a certain age threshold with on-farm or off-farm income. Younger farmers and traders are often more dynamic, agile and adventurous, and require of more formal education. The older farmers and traders often have greater access to land than the youth; hence the younger ones have a tendency to rely on some other business as their source of livelihood (Woldenhanna and Oskam, 2001).

X_3: Household size

Household size is measured in number of people in the home. The larger the household size, the greater the household demand, compelling the bread winner to find alternative ways of increasing the household income. It is, therefore, postulated that, the larger the family size the more likely that, respondent will adopt the ZECC storage technology. This was justified by Agyekum (2014), that the correlation between household size and technology adoption would have a significant influence on adoption of the ZECC storage technology. Therefore with this understanding one can expect a positive relationship between household and their influence on adoption of the ZECC.

X_4: Years of education

The number of years of education of a farmers or traders increases their general knowledge level; education makes one well informed and sharpens the way people think. People with high level of education are able to make good of the information attained during the learning process (Mignouna *et al*., 2011; Lavison 2013; Namara *et al*., 2013). The information increases framers and traders' knowledge on the importance of adopting a new technology like the ZECC storage technology and therefore, it is expected to have a positive influence on adopting the ZECC.

X_5: Marital status

Marital status of farmers and traders was expected to have either a positive or negative influence on adoption. It is assumed that, there is increase in financial responsibility for the married. Therefore, there would be a negative influence on adoption of the ZECC storage technology. On the other hand, married women in the study area confirmed that most of their assets were only obtained as a result of their husband's hard work. Meaning that marital status can also give room to a positive influence on adoption should a respondent be a female.

X_6: Membership of Group-Based Organization (GBO)

Being a member of a GBO or association related to one's career exposes the respondent to information that enables him/her to reduce uncertainty, and have access to financial support. It was expected that, membership of GBO would have a positive influence on adoption. However, rules and regulations involved of being a member in the GBO also deter some farmers and traders from having full participation of the organization.

X_7: Extension Service Received by Respondents

Extension services give respondents access to vital information and impart knowledge to respondent. Access to extension service was measured as contact with respond during farming or trading and also the frequency of visits. Extension officers are able to monitor respondents' activities and grant support through their various ministries or organizations. It is expected to have a positive influence on respondents' adoption of the ZECC storage technology.

X_8: Location

Although both study areas were in the northern region, it was chosen to help understand if their adoption rates would be different based on the fact that, they are at different geographical areas, and also, an individual's behaviour is also dependent on the environment in which they stay, location is expected to have either a positive or negative influence of the ZECC storage technology**.**

X_9: Perceived Cost of ZECC

Since the validity of the farmers' and traders' perception of high cost relative to returns in the usage of the ZECC technology cannot be ascertained, it is expected that, when the perception of farmers and traders on high cost of technology is high, there would be a negative influence on adoption of the technology and when low too the otherwise would influence adoption positively.

X_{10}: Monthly Tomato Income

With the economic theory that, the higher the income levels of respondents, the higher their purchasing power of ability to go for an extra service.(Asare,2016). Hence the a-priori expectation may either be positive and negative influence on adoption.

X_{11}: Monthly Savings

Savings helps respondents to become financially secured. It was, therefore, expected that the more savings made by respondents the higher their likelihood to use their savings for investment in the ZECC.

$X_{12:}$ Type of Person Aware (ZECC)

In ascertaining some of the factors that would influence adoption of the ZECC, farmers and traders, whom the technology has been introduced to, were needed in assessing this objective, this was to help know which of these two respondents stands a chance of adopting. Taking into consideration the different nature of their occupation, traders are expected to have a higher adoption influence as compared to farmers.

$X_{13:}$ Users of TMS

Users of existing technologies can influence the farmers or traders decision to adopt the ZECC storage technology since they have knowledge of the importance of technology user and its benefits. It is expected that, individuals who are using an existing technology would have a positive influence on the ZECC storage technology.

3.8 Identification and Ranking of Constraints Faced by Respondents in Adopting ZECC Technology

Constraints were identified through pre testing on adoption of new technology (ZECC). The Kendall's Coefficient of Concordance (W) was used in ranking the constraints tomato farmers and traders face in the usage of the ZECC storage technology in the study area. Respondents were asked to rank the identified constraints in order of most pressing to the least pressing constraint. As posited by Legendre (2005), the Kendall's Coefficient of Concordance (W) is a suitable estimator in an attempt to examine the degree to which a group of variables provide a common ranking for a set of objects.

The Kendall's Coefficient of Concordance (W) was represented as:

$$\mathbf{W} = \frac{12S}{m^2(n^3-n)-mT} \quad \textbf{(3.13)}$$

Where

$$\mathbf{S} = \sum_{i=1}^{n}(R_i - \bar{R})^2 \quad \textbf{(3.14)}$$

S = the sum of squared deviation, n = the number of constraints identified, m = the number of respondents or judges and T = the correction factor for tied ranked T = 0 if there is no ties in the rankings. The Kendall's Coefficient of Concordance (W) is a statistic of the variance of the rows sum of ranks R_i divided by the highest possible value the variance can take. This happens when all the variables are in total agreement.

The estimate for the agreement lies between $0 \leq W \leq 1$ where, W = 0 means exactly no agreement between respondents and W = 1 indicates a perfect or total agreement between respondents.

Hypotheses testing for the constraints for farmers and traders

The null hypothesis (H_0) was tested against the alternative hypothesis (H_1) as follows:

H_0: There is no agreement among tomato farmers and traders in their ranking of constraints.

$H_{1:}$ There is an agreement among tomato farmers and traders in their ranking of constraints.

3.9. Methods of Data Collection

3.9.1 Types and sources of data

Data were obtained from both primary and secondary sources. This study involved largely the use of primary data for the purpose of empirical analysis. The primary data were obtained through face-to-face interview, where a structured questionnaire was used to elicit information from farmers and traders. The primary data collected reflected the background information of the respondents such as age, educational qualification of respondents, gender, household size of respondents, farming and trading experience in terms of years, respondents' average annual income from tomatoes, the quantities of tomatoes harvested and stored within each cropping year, and the sale prices of tomatoes that were kept under the ZECC storage technology. Secondary data reflected on previous studies in relation to the study especially on the financial discounting rate and price forecasting estimations.

3.9.2 Sample size and sampling technique

The study employed a multi-stage sampling technique for the selection of hundred (100) farmers and one hundred and ten (110) traders. The Savelugu and Sagnarigu municipalities were purposively selected due to the fact that introduction of the ZECC in Ghana has been done in these two (2) municipalities. This was followed by a purposive selection of tomato farmers and traders in these municipalities due to the fact that they were the target for this study. Tomato traders were selected based on the decision to pick every other tomato seller starting from the first respondent who was picked at random. The numbers 1 and 2 were written on pieces of paper, folded and spread on the table. The number picked represented the first respondent. Thus the first tomato trader located became number 1, the second was skipped and the third chosen. This pattern was followed till the last trader in each municipality was reached.

Table 3.2 Sample Size Distribution

Municipality	Farmers	Traders	Total
Savelugu	36	54	90
Sagnarigu	64	56	120
Grand total	100	110	210

Source: Author's computation (2018)

This technique resulted in selecting 54 and 56 traders in the Savelugu and Sagnarigu municipalities, respectively. Tomato farmers were selected using the snow ball method since the total number of tomato farmers in the municipalities was unknown. A total of 36 and 64 farmers were obtained in the Savelugu and Sagnarigu municipalities respectively. A total of two hundred and ten (210) tomato farmers and traders were interviewed in these municipalities. Sample size distribution is illustrated in Table 3.2

3.9.3 Survey Instrument

The study employed a well-structured questionnaire administered to tomato farmers and traders in both closed and opened format. A preliminary questionnaire was developed and sent to three (3) research analysts for their comments. Their comments were addressed in the questionnaire for pretesting. The questionnaire was pretested specifically at Savegulu because most of the farmers and traders there were assumed to be aware of the ZECC storage technology. The pre-test was carried out in early December, 2017 to ascertain the reliability of the questionnaire in terms of clarity of the questions, avoidance of omissions, and timeliness of the questionnaire administration. The completeness and appropriateness was tested based on how respondents understood the questions asked. Observations and experience from pre-testing helped in updating and improving the final questionnaire. The questionnaire used for the primary data collection is attached as Appendix 3.1.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and describes the socio-economic characteristics of the respondents. It also presents the cost-benefit analysis of using the ZECC tomato storage technology, the factors that influence tomato farmers' and traders' adoption of the ZECC storage technology, and finally, the constraints that affect farmers' and traders' decision to adopt the ZECC storage technology.

4.2 Socio-Economic Characteristics of Respondents

The socio-economic characteristics of the respondents are presented in Table 4.1. The characteristics include: gender, age, household size, level of education, and the average monthly income generated from tomato. Gender of respondents showed that 46.19% were males made up of 40.00% farmers and 6.19% traders. Accordingly, 53.81% were females made up of 7.62% farmers and 46.19 % traders. This indicates that there are more males involved when it comes to tomato farming and more female in tomato trading in the study area. Considering the ages of the respondents, majority (58.10%) for both farmers (30.00%) and traders (28.10 %) was within the age group of 36 - 60 years. This group is classified in Ghana as the 'vibrant group' whereas those who fall below 36 were 29.04%. The remaining respondents (12.86%) of both farmers (3.81%) and traders (9.05%) were over 60 years.

The household size of respondents ranges from 1 to 12. Majority (51.43%) of the households for both farmers (27.14 %) and traders (24.29%) had household size above nine (9) members. This result gives a true picture of why the Ghana Statistical census survey reports on high household numbers in the Northern region of Ghana. There are a lot of mouths to be fed and catered for in terms of their health, education, and other bills one can think of, hence the northern sector being classified as poor as stated by the GLSS, 2010.

Table 4.1: Characteristics of Respondents

Socio-Economic Variables	**Farmer**		**Trader**		**Total**	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Gender						
Male	84	40.00	13	6.19	97	46.19
Female	16	7.62	97	46.19	113	53.81
Age						
≤ 35	29	13.81	32	15.24	61	29.05
36-60	63	30.00	59	28.10	122	58.10
60+	8	3.81	19	9.05	27	12.86
Household Size						
1-3	3	1.43	5	2.38	8	3.81
4-6	21	10.00	24	11.43	45	21.43
7-9	19	9.05	30	14.29	49	23.33
9+	57	27.14	51	24.29	108	51.43
Level of Education						
No Education	35	16.67	67	31.90	102	48.57
Basic	59	28.10	38	18.10	97	46.19
Secondary	4	1.90	5	2.38	9	4.29
Tertiary	2	0.95	0	0.00	2	0.95
Average Monthly Tomato Income						
≤ 200	67	31.90	41	19.52	108	51.43
201-400	24	11.43	53	25.24	77	36.67
401-600	9	4.29	14	6.67	23	10.95
601-800	0	0.00	2	0.95	2	0.95

Source: Field Data (2018)

Education in agriculture cannot be overemphasized given the role it plays in one's productivity. As indicated from Table 4.1, 48.57% of the respondents have had no formal education, but of others 31.9% are tomato traders. This implies that majority of respondents mainly farmers had formal education. The data implies that the level of education attained by the respondents is quite average and this is expected to influence adoption of the ZECC storage technology.

The average monthly income from tomatoes indicated that 51.43% of the respondents of which 31.9% were farmers have an average income of GHS 200 or less from their tomatoes. This indicates that most of the respondents (especially) farmers do not generate much of income from tomatoes, and can be said that, if the poorly resourced farmer or trader could adopt the ZECC storage technology their income would rise above GHS 200. Respondents generating GHS 201-400 monthly from their tomato were 36.67% of which 25.24% are trader. Very few respondents, of less than 12% (mainly tomato traders have had their monthly incomes higher than GHS 400.

4.3 Level of Awareness and Usage of the ZECC Technology

The study assessed the proportion of respondents who were aware and were using the ZECC storage technology for tomato storage. The results presented in Table 4.2, indicate that most (83.33%) of the sampled tomato farmers and traders were aware of the ZECC technology whiles a few 16.67% of them indicated that they were not aware of the ZECC tomato storage technology.

However, small proportions of the sampled respondents 26.19% (55) have adopted and have been using the ZECC storage technology for tomato storage. The majority (53.81%) of the respondents indicated that they do not use the ZECC storage technology, but the traditional method of storage such as using the jute to cover the tomatoes, and spreading the tomatoes on bare cement floor. Also, a proportion (20%) of the 210 total sampled respondents indicated that, they do not use any form of storage for their tomatoes.

Table 4. 2: Level of Awareness and Usage of ZECC Technology

	Technology Usage							
	ZECC		**TMS**		**None**		**Pooled**	
Awareness Status	No. of Resp.	%	No. of Resp	%	No. of Resp	%	No. of Resp	%
Aware:								
Farmers	10	4.76	45	21.43	24	11.43	79	37.62
Traders	45	21.23	33	15.71	18	8.57	96	45.64
Total	55	26.19	78	37.14	42	12.57	175	83.33
Unaware:								
Farmers	0	0	21	10.00	0	0	21	10.00
Traders	0	0	14	6.67	0	0	14	6.67
Total	0	0	35	16.67	0	0	35	16.67
Pooled:								
Farmers	10	4.76	66	31.43	24	11.43	100	47.62
Traders	45	21.43	47	22.38	18	8.57	110	52.38
Overall	55	26.19	113	53.81	42	20.00	210	100.00

Source: Field data (2018)

Those respondents who do not store their produce, thus the 20% of the total respondent, made it clear that, after major market days, they just leave their tomatoes at the market square for the next day's sales. They do not make any effort in storing or keeping the tomatoes in a form that will reduce deterioration. Such respondents explained that, they grade the tomatoes and price them for next day's sales according to the level of deterioration.

Out of the five reasons given for the usage of the ZECC, three of the reasons had their weighted mean index greater than 2.5(WMI> 2.5), while the other 2 reasons had an index less than 2.5 (WMI < 2.5). Table 4.3 shows that, the respondents were positive on three reasons for using the ZECC. Specifically, it ensures quality of produce; it serves as employment and increases income.

Table 4.3 Reasons for ZECC storage Technology Usage

Reasons	**Disagree 1**	**Indifferent 2**	**Agree 3**	**Total**	**WMI**	**Remark**
It ensures quality of produce	0	14	144	158	2.9	Agree
It serves as employment	1	24	126	151	2.7	Agree
It increases shelf life	2	62	66	130	2.4	Indifferent
It increases income	0	32	117	149	2.7	Agree
Because others are using it	22	46	30	98	1.8	Indifferent

Source: Computed from field data (2018)

The reasons why some of the respondents were not using the ZECC even though they were aware of it were three fold. All of the three reasons given for continuing with the existing method (TMS) had the weighted mean index greater than 2.5 (WMI> 2.5). This is presented in Table 4.4 revealing that, all the respondents were positive on the three reasons for using the TMS. Specifically, they claimed that the TMS is less costly, reduces spoilage and that because others are using it.

Table 4.4 Reasons for TMS storage Usage

Reasons	Disagree 1	Indifferent 2	Agree 3	Total	WMI	Remark
It is less costly	1	22	303	326	2.9	Agree
It reduces spoilage	3	56	246	305	2.7	Agree
Because others are using it	2	36	279	317	2.8	Agree

Source: computed from field data

4.4 Comparing Cost and Benefits of the ZECC Tomato Storage Technology

4.4.1 Capital costs estimation

The average capital cost items are presented in Table 4.5. These items include bricks, bamboo sticks, and sand among others. Quantities of items and unit prices were averages estimated based on information from the field.

Table 4. 5: Average Capital Cost for a 50-Kilogram Capacity ZECC Facility

Capital Cost	Quantity	Unit Price (GHS)	Value (GHS)	Useful Life
Bricks	400 pieces	0.80	320.00	15
Bamboo	10 sticks	2.00	20.00	2
Sand	80 kg	0.025	2.00	-
Watering can	1 unit	6.00	6.00	3
Crates (35kg)	3 units	4.17	12.51	3
Shovel	1 unit	25.00	25.00	3
Knapsack sprayer	1 unit	90.00	90.00	5
Bucket	1 unit	2.00	4.00	2
Pipe hole	722 metres	0.17	122.74	3
Labour cost for building	2 man-days	45.00	90.00	
Total Capital Cost			**692.24**	

Source: Compiled from field data (2018)

For a 50-kg capacity ZECC storage technology, it was estimated that a total of six hundred and ninety-two Ghana cedis, twenty- four pesewas (GHS692.24) was needed at the study area.

4.4.2 Average operating budget estimation

Table 4.6 presents the average annual estimates for a 50kg capacity for the ZECC storage technology. Quantities of items and unit prices were averages estimated based on information from the field. It was found that, an average total revenue of GHS 3,588.34 was attained annually in using the ZECC for storing tomatoes. This includes revenues obtained when the ZECC storage facility owners render service to non-facility owners in storing their produce at a charge. The total operating cost for the year amounted to GHS 2,505.19.

Average Operating Budget

The average operating budget for the 50-kilogram capacity ZECC facility is illustrated in Table 4.6. This includes items like tomatoes, dry palm fronds, napkins, and insecticides among others. The main type of labour in the storage consists of loading and off-loading the tomatoes, watering of bricks, sorting, and cleaning of the ZECC storage technology. Regular wetting of the laid bricks results in wearing off and requires occasional repairs and maintenance.

Additionally, services are provided in the replacement of palm fronds as and when they are out of use. In all, maintenance is done averagely five times a year at an average cost of GHS60.00 each. Average net cash flow was GHS 1,083.15 and it shows higher benefits than costs.

Table 4. 6: Average Operating Budget for a 50-Kilogram Capacity ZECC Facility

	Quantity/Year	Unit Price (GHS)	Value (GHS)
Revenue			
Sales	432.6 kg	1.36	588.34
Services	50 requests	60.00	3,000.00
Total Cash Inflow			**3,588.34**
Operating Costs			
Materials:			
Tomatoes	525 kg	0.86	452 .00
Dry palm fronds	24 bundles	2.00	48.00
Napkin	10 pieces	2.00	20.00
Insecticides	96 kg	5.00	480.00
Dust Bin	1 unit	5.00	5.00
Broom	4 units	1.00	4.00
Water	11,232 litres	0.006	67.39
Labour	120 man-days	10.00	1,200
Transport	50 kg-metres	1.00	50.00
Repairs & Maintenance	5 times	12.00	60.00
Sub-Total			2,385.89
Contingencies	5% of operating cost		119.29
Total Operating Cost			2,505.19
Total Cash Outflows			2,505.19
Net Cash Flow			**1,083.15**

Source: Compiled from field data (2018)

4.4.3 Cash Flow Projections

Net Cash Flows

On the basis of the assumptions stated in the methodology, the net cash flow projections for the ZECC, TMS and the incremental were generated as in Table 4.7. Discounting the cash flows for the ZECC storage technology at 21% discount rate yielded a Net Present Value (NPV) of GHS 6, 436.15 whiles discounting the cash flow projection for tomato storage under the TMS at 21% yielded a Net Present Value (NPV) of GHS 2, 699.41. Similarly, the ZECC and the TMS yielded Benefit-Cost Ratios of 1.52 and 1.09, respectively which are both greater than 1.00. These indicate that both ZECC storage technology and the existing TMS are both financially viable in the Savelugu and Sagnarigu municipalities, although the ZECC storage technology had a higher NPV.

Table 4.7: Net Cash Flows for ZECC and TMS (in Ghana Cedis)

Years	ZECC	TMS	Incremental
0	(755.11)	(50.27)	(704.84)
1	372.77	81.30	291.47
2	1,063.15	528.42	534.73
3	2,093.77	781.48	1,312.29
4	2,059.71	776.71	1,283.00
5	2,029.46	796.38	1,233.08
6	2,067.83	755.19	1,308.65
7	2,086.13	792.82	1,293.32
8	2,049.27	771.49	1,277.79
9	2,080.19	774.69	1,305.50
10	2,002.33	771.49	1,230.85
11	2,086.14	792.82	1,293.32
12	2,059.91	761.65	1,298.26
13	2,102.72	777.11	1,325.61
14	2,082.72	803.78	1,278.94
15	2,197.67	813.98	1,383.69
NPV@ 21% DR	**6,436.15**	**2,699.41**	**3,739.32**
BCR @ 21%DR	**1.52**	**1.09**	
CBR@21%DR	**0.66**	**0.92**	

Source: Computed from field data, as in Appendices 4.4, 4.5, & 4.6 (2018)

The results from the table revealed that discounting the incremental net cash flow gave an incremental Net Present Value of GHS3, 739.32. The positive incremental NPV indicates that the ZECC storage technology is more profitable than the Traditional Method of storage in the study area.

Sensitivity Analysis Using Switching Values

The switching values computed in determining the sensitivity analysis were derived from the Benefit-Cost Ratio (BCR) of 1.52 and Cost-Benefit Ratio (CBR) of 0.66 for the

ZECC. By examination, BCR minus 1 gave 0.52, while 1 minus CBR gave 0.34. This implies that cost would have to increase by 52 percent or benefits to fall by 34 percent for the investment to break-even. In either case, the percentage value implies that an increase in cost beyond 52 percent or decrease in benefit beyond 34 percent would give a negative NPV or a BCR of less than one, and the investment would no longer be financially viable.

The cost driver in this study is labor cost of the tomatoes, followed by insecticide cost and then the cost of tomatoes. A report by the Statistics, Research and Information Directorate in 2015 on nominal weighted average rural wholesale prices of tomato over the period 2006 to the year 2015 gives an average annual increase of 26.18% which is far less than the 52 percent cost increase that would make the investment break-even.

Table 4.8: Annual Nominal Weighted Average Rural Wholesale Tomato Prices (GHS/Mt)

Years	Prices (GHS)	Growth rate
2006	575.48	-
2007	649.44	12.86
2008	899.83	38.55
2009	1503.30	67.00
2010	1449.23	-3.60
2011	1962.97	35.45
2012	2573.74	31.11
2013	3305.37	28.43
2014	4253.09	28.67
2015	5246.83	23.37
Mean Growth Rate		26.18

Source: Statistics, Research and Information Directorate, MoFA (2015)

This gives an indication that NPV will never get to zero or less over the investment period. Table 4.8 gives the annual nominal weighted average rural wholesale prices and growth rate of tomato from the year 2006 to 2015.

4.5 Factors Influencing Adoption of the ZECC by Farmers and Traders

Table 4.9 presents the results of the probit regression model on factors that influence adoption of the ZECC storage technology. Results of the Probit model (ZECC) showed a pseudo R^2 of 0.903 which indicates that about 90% of the variation in the farmers' and traders' adoption of the ZECC is jointly influenced by the independent variables. The probability value of 0.000 of the Wald chi-square statistics suggests that the independent variables explained the farmers' and traders' adoption of the ZECC storage technology.

Results of the probit regression presented in Table 4.9 revealed that, age, marital status and location (community) of respondent were not statistically significant to influence adoption of the ZECC technology among tomato farmers and traders in the selected municipalities. However, some explanatory variables were found to be statistically significant.

Gender of the respondents was positive and statistically significant at 1% level. Given that a respondent is a male, then the probability of him to adopt a ZECC technology increases by 0.03 percent than a female respondent. This results satisfies the expected a-priori based on the fact that, the women in this study area have lesser access to properties needed for investment. Also, findings from this study is in line with the study done by Obisesan (2014) on gender differences and technology adoption in Nigeria.

Table 4.9: Results of Probit Model

Variables	Coefficients	Standard errors	P-Value	Marginal effects
Gender	1.6340	0.6426	0.011	0.0315**
Age	-0.0347	0.0281	0.216	-0.0004
Household Size	-0.3264	0.1310	0.013	-0.0039**
Years of Education	1.4648	0.3676	0.000	0.0175**
Marital status	-0.3864	0.4027	0.337	-0.0046
GBO	1.6561	0.7600	0.029	0.0382**
Extension	1.3391	0.6845	0.050	0.0427**
Location	0.1874	0.9438	0.843	0.0019
Perceived Cost of ZECC	-2.9363	1.0654	0.006	-0.1876***
Monthly Tomato Income	0.0040	0.0020	0.051	0.00005***
Savings	-1.3161	0.5556	0.018	-0.0145**
Type of Person Aware of ZECC	1.1514	0.5338	0.031	0.02687**
User of TMS	-3.5968	1.4800	0.015	-0.0406**
Constant	1.6469	2.2445	0.463	0.0000
Model Diagnostics				
Number of observations	= 175			
Wald Chi2(13)	= 62.07			
Prob. > Chi2	= 0.000			
Pseudo R^2	= 0.903			

Variables with ***, **** and ******* are statistically significant at **10%, 5%** and **1%** respectively

Source: Author’s Computation from field data (2018)

Household size of the respondent significantly influences ZECC technology. Results as presented in Table 4.9 show that, an increase in the size of the household by one person would decrease the probability of adopting by 0.0004 percent. This result however does not satisfy the a-priori expected .it further disagrees with the study by (Mignouna *et al.*, 2011 and Bonabana- Wabbi 2002). Their report revealed that, household size is simply used as a measure of labor availability. It determines adoption process in that, a larger household have the capacity to relax the labor constraints required during introduction of a new technology.

Years of Education of the respondent was also positive and significant as indicated in Table 4.9. The results indicated that a one year increase in the years of a tomato farmer's or trader's education (schooling) increases the probability of adopting the ZECC technology by 0.02 percent. This study result on education is similar to the findings of Uematsu & Mishra (2010).

Membership of GBO (Group-Based Organization) was positive and statistically significant. Given that a tomato farmer or trader is a member of a Group-Based Organization, then his or her probability of adopting the ZECC storage technology increases by 0.0382%.

Extension visits in terms of the number of times a tomato farmer or trader had contacts to an extension officer per year was positive and significant to influence a tomato farmer and trader to adopt the ZECC technology. A one unit increase in the number of extension visits received by a tomato farmer or trader increases his or her probability of adopting a ZECC by 0.0427%. It can be established that, where extension visits serves its main purpose; thus providing knowledgeable information to a farmer or trader, it helps in a faster rate of adoption. This results meets the expected a-priori. The positive relationship between extension and the factors that would influence adoption of the ZECC storage technology is similar to that of Uaiene *et a*l., (2009). They reported in their study that, whenever farmers are exposed to needed and essential information concerning an innovated technology, it influences their decision to adopt such a technology.

Perceived Cost of ZECC technology negatively influences respondents to adopt the Zero Energy Cool Chamber storage technology. As presented in Table 4.9, a one Ghana cedi increase in the perceived cost of ZECC decreases adoption of ZECC technology by 0.2 percent. This gives a true reflection of the fact that, farmers and traders who perceive higher cost of adopting the ZECC storage technology would either choose to use the traditional storage method or decide not to store their produce at all. The result obtained in this study is in line with what was reported by Kinyangi (2014) on determinants of technology adoption by rural farmers and traders. It also, gives a true reflection of why most of the respondents are aware of the ZECC storage technology but do not use it in the first objective.

Monthly Tomato Income received per season was also positive and statistically significant at 1% level. Results presented in Table 4.9 indicated that a one Ghana cedi increase in the incomes generated from tomato farming and trading increases the probability of adopting the ZECC storage technology by 0.00005%. This result is also in line with the economic theory that, the higher the income of an individual, the higher the individual's ability to purchase, *ceteris paribus*.

Monthly Savings was significant and had a negative influence. The results indicate that, when savings increases by one Ghana Cedis, the probability of adopting the ZECC storage decreases by 0.02 percent**.** Savings gives the opportunity to have access to money. It is obvious that, when an individual have money, that is when that individual can decide to invest into a particular investment, and the vice versa holds for it. Most banks in Ghana normally give our loans based on your saving ability, amount saved and your frequency of depositing. This is the baseline most rural banks use.

Type of person aware of ZECC storage technology was significant. Results of the table 4.9 revealed that, a trader's probability increase by 0.03 percent when the person who wants to adopt is a trader. This result is also in connection with the reasons why most of the respondents using the ZECC storage technology are traders as analysed and revealed by the objective one.

User of TMS as a factor had a negative influence on the adoption of the ZECC storage technology. The results on this factor showed that, being a user of the traditional storage method decreases the probability of adopting the ZECC by 0.04 percent. This result shows that the farmers and traders are conservative, and gives a clear explanation on why most of the farmers and traders are still using the existing method of storage although they are aware of the ZECC storage technology. Although it was expected that, a user of an existing technology is likely to adopt a new technology, this result showed the otherwise of the a-priori expectation.

4.6 Identification and Ranking of Constraints Faced by Farmers and Traders

4.6.1 Constraints faced by farmers

As presented in Table 4.10, the computed Kendall's Coefficient of Concordance (W) statistics was 0.91 which is significant at 5%. This means that there is 91% agreement among the tomato farmers (who are using the ZECC) in rankings of the constraints faced in adopting and or using the ZECC storage technology. This means that, the null hypothesis which specifies that there is no agreement among the farmers in rankings of constraints is rejected. Since then $P\text{-}Value = 0.000 < 0.05$, it shows that there is an agreement among the farmers in ranking of constraints faced in adopting the ZECC storage technology.

Results presented in Table 4.10 indicate the mean scores with the least scores showing the major constraints. Sampled tomato farmers identified and ranked access to credit'' as the first most pressing constraint to adopting the ZECC storage technology. It was followed by animal disturbances and scarcity of water as third ranked constraint.

Table 4. 10: Ranked Constraints of Farmers

Constraint	Mean Score	Rank
Access to Credit	1.186	1st
Animal Disturbances	2.138	2nd
Scarcity of Water	3.024	3rd
High Cost of Storage Inputs	4.052	4th
High cost of maintenance	5.000	5th
Time demanding	6.000	6th
N = 10	**Degrees of Freedom = 5**	**Chi-Square = 154.189**
Kendall's (W) = 0.91	**Asymptotically Significant: P – Value = 0.00 < 0.05**	

Source: Field data (2018)

High cost of storage inputs, high cost of maintenance and time demanding ranked 4th, 5th, and 6th constraints faced by farmers in using the ZECC storage technology respectively. The results of this study on the constraints or challenges faced by rural households in technology adoption confirms what was reported by Robinson *et al.*, (2012) and Muzari (2012) in their studies.

4.6.2 Constraints Faced by Traders

Results presented in Table 4.11 indicated the ranked constraints faced by tomato traders. Tomato traders (who are using the ZECC) identified and ranked high cost of transportation (mean score = 1.189) as the first most pressing constraint in adopting the ZECC storage technology followed by high cost of storage (mean score = 2.132) as second. Limited storage facilities as third constraint and time demanding (mean score = 4.052) as the last but not the least constraint faced in adopting the ZECC storage technology. The result of the constraints or challenges faced by farmers and traders in the study area is not different from that of those reported by Robinson *et al*., (2012) in the study of technology adoption by rural household at India and Tanzania, respectively.

Table 4.11 Ranked Constraints of Traders

Constraint	Mean Score	Rank
High Cost of Transportation	1.189	1st
High Cost of Storage	2.132	2nd
Limited Storage Facilities	3.014	3rd
Time Demanding	4.052	4th
N = 45	**Degrees of Freedom = 3**	**Chi-Square = 630.77**
Kendall's (W) = 0.89	**Asymptotically Significant: P – Value = 0.00 < 0.05**	

Source: Field data (2018)

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter of the study presents the summary of main findings, conclusions, and suggested recommendations from the study for policy implications.

5.2 Summary

The study described the level of awareness and adoption of the ZECC storage technology among tomato farmers and traders in the Northern Region of Ghana. It further evaluated Cost-Benefit analysis of using the ZECC tomato storage technology. Also, the study examined the factors that influence tomato farmers and traders to adopt the ZECC storage technology. Finally, the study identified constraints that affect farmers and traders in the usage of the ZECC tomato storage technology.

The study was conducted on a 210 sampled tomato farmers and traders in the Savelugu and Sagnarigu municipalities. The study used a well-structured questionnaire designed in closed and open format. Pretesting was done to examine the validity and reliability of the data collection instrument. The study used descriptive statistics such as frequencies, percentages, and means. The Benefit-Cost analysis, the probit regression model, and the Kendall's Coefficient of concordance (W) to address the set objectives.

The results show that the majority of respondents (53.80%) were females. The household size of respondents ranges from 1 to 12. Majority (51.40%) of the households had household size above ten (10) members. Findings indicated that most (83.33%) of the sampled tomato farmers and traders were aware of the ZECC storage technology.

On the other hand, a small proportion of the respondents (26%) (less than one-third of those who were aware) have adopted the ZECC technology whiles a larger proportion of about 74% of the respondents indicated that, they do not use the ZECC technology but either use the traditional methods of tomato storage (53.81%) or do not use any form of storage. Reasons given for using the ZECC storage technology included its ability to ensure quality of the tomato, serving as a source of employment, and increasing the shelf life of the tomato among others. On the other hand, farmers and traders who were aware of the ZECC storage technology but prefer to continue with the traditional method of storage also gave reasons being that, it is less costly, reduces spoilage of their tomatoes and lastly simply because other people are using it.

The results of the Benefit-Cost analysis indicated a BCR of 1.52 and an NPV of GHS6, 436.15 for ZECC and an NPV of GHS2, 699.41 and BCR of 1.09 for the traditional method of storage at 21% discount rate. The NPVs of both technologies gave an incremental NPV of GHS3, 739.32. This implies that both the ZECC and the TMS are financially viable but the ZECC is more profitable.

The probit model for the ZECC technology showed a pseudo R^2 of 0.903 which indicates that, about 90% of the variation in the farmers' and traders' adoption of the ZECC storage technology is influenced by the independent variables. Results of the probit regression revealed that gender, household size, marital status, years of education, GBOs, extension visits, tomato income, savings, types of persons aware of the ZECC, perceived cost of the ZECC storage technology and users of the TMS were statistically significant in influencing the adoption of the ZECC storage technology among tomato farmers and traders in the study area.

Also, Kendall's Coefficient of Concordance (W) statistics was 0.91 and significant at 5%. This showed that there was 91% agreement among the tomato farmers and traders in the rankings of the constraints faced in adopting the ZECC storage technology. For farmers, 'access to credit', 'animal disturbances', and 'scarcity of water' were ranked as first, second and third most pressing constraints, among others. Traders, also ranked 'high cost of transportation', 'high storage charges', and 'limited storage facilities' as their most pressing constraints, among others.

5.3 Conclusions

The study concluded, based on the findings that although most of the sampled respondents were aware of the ZECC storage technology the majority do not see the need for using it. The Benefit-Cost ratios (BCRs) and Net Present Values (NPVs) showed that the ZECC technology is more financially viable than the existing method of storage.

Factors that significantly influenced the ZECC storage technology adoption were: gender, years of education, GBOs, extension visits, tomato income, and perceived cost of the ZECC storage technology. Based on these findings, improvements targeted at male farmers and traders on factors identified would increase the probability of adopting the ZECC storage technology. Both farmers and traders face a number of peculiar constraints which need to be addressed, notable among them being ''access to credit'' and ''high cost of transportation'' respectively.

5.4 Recommendations

The following recommendations have been suggested based on the findings of the study:

1. There is a need to increase smallholder farmers' and traders' education on the significance of adopting modernized technologies like the Zero Energy Cool Chamber storage technology (ZECC). Currently, modern storage technologies improve the life span of perishable commodities like tomatoes, and other fruits and vegetables. Therefore, there would be a great farming and agribusiness success if farmers and traders are educated to adopt new technologies that would assist them in their farming businesses rather than the continued reliance on the traditional storage methods. The agriculture training institutions like the Agricultural training colleges in the country should channel their students to places like Savelugu and Sagnarigu during internship to help sensitize the key importance of adopting the ZECC storage technology to farmers and traders. Agribusiness related NGOs like Alliance for the Green Revolution in Africa (AGRA) should place keen attention on farmers' and traders' education and training programmes on modern technology adoption since their major policy is to help millions of small-scale farmers and traders lift themselves out of poverty and hunger.
2. Zero Energy Cool Chamber (ZECC) storage technology proves to be a financially viable technology for tomato storage in the Northern Region. It is recommended that the Ministry of Food and Agriculture and NGOs like GIZ should subsidize the cost of providing facilities like the ZECC storage technology for the rural or remote farming communities in order to prevent and/or reduce the frequent tomato post-harvest losses as a result of lack of cold storage technology or poor storage systems

in such areas in the country. Also Rural and Agricultural financial institutions like Agricultural Development Bank (ADB) should assist farmers and traders (by granting them loans applied for) to build storage facilities like the ZECC.

3. Socio-economic factors including gender (particularly males), years of education, membership of group-based organizations, extension visits, tomato income and perceived cost of ZECC technology should be given close attention by agricultural agents, especially extension officers, in the course of providing their services to the rural tomato farmers and traders. It is recommended that the extension-to-farmer ratio be improved upon to enable extension officers pay frequent visits to farmers and traders to educate them on modern storage culture of raw farm produce.
4. Since the major constraints faced by tomato farmers in adopting the ZECC tomato storage technology were: access to credit, animal disturbances, and scarcity of water; and 'high cost of transportation', 'high cost of storage', and 'limited storage facilities' for traders in the Northern Region, It is therefore, recommended that, development agencies tailor their development plans and projects towards provision of subsidized credit, reduced cost of building storage facilities, and addressing other challenges that hinder the ZECC usage in the Northern Region of Ghana.

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APPENDICES

APPENDIX 3.1: QUESTIONNAIRE FOR THE STUDY

UNIVERSITY OF GHANA, LEGON

DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS

This questionnaire is to gather data on the topic: Financial Viability and Adoption of the ZECC Storage Technology for Tomato storage in the Savelugu and Sagnarigu municipalities in the Northern Region of Ghana. Please this is for an academic purpose only therefore information provided will be treated with confidentiality.

Questionnaire Number: ………… **Name of Enumerator …………………….**

Date of interview: …………… **Please kindly tick where necessary.**

Location………………….

A. Socio – Economic characteristics of farmers and traders

1. Gender 1 = Male [ ] 0 = Female [ ]
2. Household size …………………………………………
3. Age of respondent ………………………………………….
4. What are your years of formal education? ……………………….
5. Highest Educational Qualification obtained? 0 = None [ ] 1 = Primary [ ] 2= JHS [] 3 = SHS/Vocational/Technical 4 = Tertiary [ ] 5 = Other ( ) ……
6. What is your marital status? 1=Single [ ] 2=Married [ ] 3=Divorce/separated [ ] 4= widowed [ ]
7. What is your major occupation?...
8. What are the other occupation(s) in other of priority? ....
9. Do you belong to any Farmer Based or Market Organization (GBO)? 1=Yes [ ] 0=No[]
10. If yes what is the name of that Organization? ………………………………….
11. Do you have contact with extension/market officer(s)? 1= Yes [ ] 0= No [ ]
12. If yes, how often do they contact you? 1= Weekly [ ] 2. Monthly [ ] 3. Others (specify)…...
13. What is the ownership of the Land you use for storing? 1= Own 2 = Relatives 3 = Renting 4 = Not Applicable
14. If renting, how much do you pay a month?....................
15. Please which of these communities is your tomato storage located? 1= Savelugu, 2= Sagnarigu
16. What are your source of financing your tomato business? 1= self 2= relatives 3= Bank
17. How much income do you get monthly in the tomato cultivation?............................

18. Do you cultivate/sell other crops aside tomatoes? 1= Yes [ ] 0= No [ ]
19. How much money do you get from the other crops each month? …………………
20. How much income do you get from other occupation(s) month?.................................
21. What is your total average monthly income?...................................
22. Do you save? 1=yes 0=no
23. On average, how much do you save monthly? GH¢…………………
24. Do you store your tomatoes? 1= yes 0= No
25. What is your minimum quantity stored at a time for the market? ....
26. What is your maximum quantity stored at a time for the market? ....
27. Please since when have you been storing your tomatoes?……………………
28. For how long do you store your tomatoes? Less than 7 days [ ] One week [ ] About Two weeks [ ]
29. Do you get any financial assistance in your storage business? 1= Yes [ ] 0 = No [ ]
30. If yes, from where? 1= relatives 2= Bank 3= other (specify)…………………………

Awareness of ZECC Method and other Tomato Storage Techniques

(ZECC is a brick layered rectangular shaped structures that requires zero energy to operate, it provides cooling environment that prolongs the shelf life of produce. These produce are mainly fruits and vegetables.)

31. Are you aware of the Zero Energy Cool Chamber (ZECC) used for tomato storage? 1= Yes 0=No
32. If yes do you use it? 1= Yes 0=No
33. If you use it, how much does it cost on the average...
34. If you don't use it why don't you...
35. Are you aware of any other storage technique used for tomato storage? 1= Yes 0=No
36. If yes what is it? ………………………………………………………
37. If you are aware do you use it? 1= Yes 0=No
38. If you use it, how much does it cost...
39. If you are aware but you do not use it, why don't you? ………
40. Which of the following would be your reason for using the **Zero Energy Cool Chamber**?

Please tick where appropriate.

Reasons for adopting Zero Energy Cool Chamber	**1= disagree**	**2= Indifferent**	**3= agreed**
It ensures quality of produce			
It serves as employment			
It increases shelf life			
It increases income			
Because others are using it			

41. Which of the following would be your reason for using the Other Storage Technique? Please tick where appropriate

Reasons for adopting other Storage	1= disagree	2= Indifferent	3= agreed
It is less costly			
It reduces spoilage			
Because others are using it			

Assessing the costs and benefits of using the Zero Energy Cooling Chamber

42. Please indicate the quantities and unit prices of the materials used for your tomato storage.

Capital cost

ITEMS	SIZE	QUANTITY	COST
Land			
Pipe holes			
Tomato crates			
Jute cloth			
Bricks			
Bamboo			
Reefs			
Shovel			
Knapsack sprayer			
Sand			
Watering can			
Bucket			
Others (specify)			

Material Input

Items	Quantity	Unit price
Tomatoes		
Insecticide		
Dry grass		
Broom		
Water		
Napkin		
Dust collector		
Others(specify)		

Labour Input

Activity	Tech.	Capacity of storage facility	No. of Males	No. of Females	No. of Chn	No. of Days Worked	Wages
Debris collection and burning							
Sorting							
Watering							
Cleaning							
Loading and off loading							
Others(specify)							

Services

Activity	Cost
Transportation	
Repairs & Maintenance	
Hiring other than transport	
Utilities	
Others(specify)	

Revenue from Tomato Storage (ZECC)

Type of Tomatoes stored	Frequency of storage	Quantity of storage	No. of sales per batch	Total quantity of sales	Total Quantity sold after storage	Unit Price

Revenue from Other Tomato Storage

Type of Tomatoes stored	Frequency of storage	Quantity of storage	No. of sales per batch	Total quantity of sales	Total Quantity sold after storage	Unit Price

44. Constraints Faced in Adopting the ZECC Tomato Storage Technology

Please kindly rank the constraints faced in order of 1 = most pressing constraint to least constraint.

Constraints	**Rankings**
Inadequate storage facilities	
High cost of maintenance	
High cost of Transportation in going to store	
High cost storage charges	
Access to credit	
Animal Disturbances	
Scarcity of water	
Time demanding	
Limited storage facilities	
Others(specify)	

Thank you for your time

APPENDIX 4.1 AVERAGE CAPITAL COST ESTIMATION FOR TRADITIONAL METHOD STORAGE METHOD (TMS)

CAPITAL ITEMS COST	UNIT	QUANTITY	UNIT PRICE	VALUE	USEFUL LIFE
Jute Sack	Pieces	4 pieces	6.00	24.00	2 years
Bucket	Litre	5616 litres	0.006	33.696	2 years
Crates(35kg)	Kg	3units	5.00	15.00	3 years
TOTAL COST				72.696	

APPENDIX 4.2 AVERAGE ANNUAL OPERATING BUDGET FOR TRADITIONAL METHOD OF STORAGE (TMS)

	QUANTITY	UNIT PRICE (GHS)	VALUE (GHS)
Revenue			
Sales	4495.4	1.36	6113.744
Total Cash inflow			6113.744
Operating Costs (Recurrent Costs)			
Materials			
Tomatoes	5460kg	0.86	4695.60
Dust Bin	1unit	5.00	5.00
Broom	4units	1.00	4.00
Water	5616liters	0.006	33.696
Labour	60man-days	10.00	600.00
Transport	50kg-metre	1.00	50.00
Maintenance	5 times	6.00	30.00
Contingencies	5%		145.6988
Total Operating Cost			5563.9948
Total Cash Outflow			5636.6908
Net Cash Flow			549.7492

APPENDIX 4.4: CASH FLOW PROJECTION FOR ZECC STORAGE TECHNOLOGY

YEARS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
REVENUE																
Sales	0	394.19	588.34	784.25	784.25	784.25	784.25	784.25	784.25	784.25	784.25	784.25	784.25	784.25	784.25	784.25
Service Charges	0	2,250.00	3,000.00	3,999.00	3,999.00	3,999.00	3,999.00	3,999.00	3,999.00	3,999.00	3,999.00	3,999.00	3,999.00	3,999.00	3,999.00	3,999.00
TOTAL REVENUE	0	**2,644.19**	**3,588.34**	**4,783.25**	**4,783.25**	**4,783.25**	**4,783.25**	**4,783.25**	**4,783.25**	**4,783.25**	**4,783.25**	**4,783.25**	**4,783.25**	**4,783.25**	**4,783.25**	**4,783.25**
RESIDUAL VALUE																
Bricks	0															37.41
Bamboo	0		2.00		2.00		2.00		2.00		2.00		2.00		2.00	10.00
Sand	0															2.00
Watering Can	0					1.70					1.70					1.69
Crates(35kg)	0			1.30			1.30			1.30			1.30			1.25
Shovel	0				8.14				8.14				8.14			9.39
Knapsack Sprayer	0					30.50					30.50					30.47
Bucket	0		2.00		2.00		2.00		2.00		2.00		2.00		2.00	2.00
Pipe hole	0			0.75			0.75			0.75			0.75			0.75
TOTAL RESIDUAL VALUE	0	-	4.00	2.05	12.14	32.20	6.05	-	12.14	2.05	36.20	-	14.19	-	4.00	94.95
TOTAL CASH INFLOW	0	**2,644.19**	**3,592.34**	**4,785.30**	**4,795.39**	**4,815.45**	**4,789.30**	**4,783.25**	**4,795.39**	**4,785.30**	**4,819.45**	**4,783.25**	**4,797.44**	**4,783.25**	**4,787.25**	**4,878.21**
CAPITAL COST																
Bricks	320															0
Bamboo	20		20		20		20		20		20		20		20	0
Sand	2															0
Watering Can	6					6					6					0
Crates(35kg)	12.51			5			5			5			5			0
Shovel	25				25				25				25			0
Knapsack Sprayer	90					90					90					0
Bucket	4		4		4		4		4		4		4		4	0
Pipehole	122.74			3			3			3			3			0
Contingency	34.61															
Labour Cost For Building	90															0
TOTAL CAPITAL COST	**726.86**	**0**	**24**	**8**	**49**	**96**	**32**	**0**	**49**	**8**	**120**	**0**	**57**	**0**	**24**	**0**

APPENDIX 4.4: CASH FLOW PROJECTION FOR ZECC STORAGE TECHNOLOGY (CONT'D)

YEARS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
OPERATING COST																
Materials																
Tomatoes		302.51	451.5	601.85	601.85	601.85	601.85	601.85	601.85	601.85	601.85	601.85	601.85	601.85	601.85	601.85
Dry Palm Fronds		48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
Napkin		20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Insecticide		480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
Dust Collector		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Broom		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Water		67.39	67.39	67.39	67.39	67.39	67.39	67.39	67.39	67.39	67.39	67.39	67.39	67.39	67.39	67.39
Labour		1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00
Transport		33.5	50	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65
Repairs and maintenance		0	60	63	66.15	69.4575	72.930375	76.5768938	76.58	76.58	76.58	76.58	76.58	76.58	76.58	76.58
Contingencies	28.25	111.02	119.29	127.64	127.64	127.64	127.64	127.64	127.64	127.64	127.64	127.64	127.64	127.64	127.64	127.64
TOTAL OPERATING COST	755.11	2,271.42	2,505.19	2,683.54	2,686.69	2,689.99	2,693.47	2,697.11	2,697.12	2,697.12	2,697.12	2,697.12	2,697.12	2,697.12	2,697.12	2,697.12
TOTAL CASH OUTFLOWS	**755.11**	**2,271.42**	**2,529.19**	**2,691.54**	**2,735.69**	**2,785.99**	**2,725.47**	**2,697.11**	**2,746.12**	**2,705.12**	**2,817.12**	**2,697.12**	**2,754.12**	**2,697.12**	**2,721.12**	**2,697.12**
NET CASH FLOW	-755.11	372.76827	1,063.15	2,093.77	2,059.71	2,029.46	2,063.84	2,086.14	2,049.28	2,080.19	2,002.34	2,086.14	2,043.33	2,086.14	2,066.14	2,181.09
DISCOUNT FACTOR AT 21 % DR	1	0.83	0.68	0.56	0.47	0.39	0.32	0.26	0.22	0.18	0.15	0.12	0.1	0.08	0.07	0.06
DISCOUNTED CASH INFLOW	0	2,185.15	2,453.57	2,701.30	2,237.05	1,856.36	1,525.87	1,259.43	1,043.48	860.87581	716.170551	587.38333	486.94035	401.31483	331.75656	280.98469
DISCOUNTED CASH OUTFLOW	755.11	1,877.10	1,727.43	1,519.37	1,276.20	1,074.00	868.33361	710.149845	597.55486	486.650382	418.623449	331.20585	279.54278	226.28804	188.57334	155.35389
DISCOUNTED NETCASH FLOW	-755.11	308.055698	726.13104	1,181.93	960.852762	782.3561797	657.53797	549.280377	445.92242	374.225428	297.547102	256.17748	207.39757	175.02679	143.18321	125.63081
NPV AT 21%	6436.146															

APPENDIX 4.5 : CASHFLOW FOR TMS

YEARS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sales	0.00	4096.21	6113.74	8149.62	8149.62	8149.62	8149.62	8149.62	8149.62	8149.62	8149.62	8149.62	8149.62	8149.62	8149.62	8149.62
RESIDUAL VALUE																
Jute Sack	0.00		2.67		2.67		2.67		2.67		2.67		2.67		2.67	12.00
Bucket	0.00		0.00	0.39			0.39			0.39			0.39			0.39
Crates	0.00		0.00	0.48			0.48			0.48			0.48			0.48
TOTAL RESIDUAL VALUE	0.00	0.00	2.67	0.87	2.67	0.00	3.54	0.00	2.67	0.87	2.67	0.00	3.54	0.00	2.67	12.87
TOTAL CASH INFLOW	**0.00**	**4096.21**	**6116.41**	**8150.49**	**8152.29**	**8149.62**	**8153.16**	**8149.62**	**8152.29**	**8150.49**	**8152.29**	**8149.62**	**8153.16**	**8149.62**	**8152.29**	**8162.49**
CAPITAL COST																
Jute Sack	24.00		24.00		24.00		24.00		24.00		24.00		24.00	24.00		
Bucket	4.00		0.00	4.00			4.00			4.00			4.00			
Crates	15.00		0.00	15.00			15.00			15.00			15.00			
Contingencies 5%	3.64															
TOTAL CAPITAL COST	**46.64**		**24.00**	**19.00**	**24.00**	**0.00**	**43.00**	**0.00**	**24.00**	**19.00**	**24.00**	**0.00**	**43.00**	**24.00**	**0.00**	
OPERATING COST																
Materials																
Tomatoes		3146.05	4695.60	6259.23	6259.23	6259.23	6259.23	6259.23	6259.23	6259.23	6259.23	6259.23	6259.23	6259.23	6259.23	6259.23
Dust Bin		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Broom		4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Water		33.70	33.70	33.70	33.70	33.70	33.70	33.70	33.70	33.70	33.70	33.70	33.70	33.70	33.70	33.70
Labour		600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
Transport		33.50	50.00	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65	66.65
Repairs & maintenance		0.00	30.00	31.50	33.08	34.73	36.47	38.29	38.29	38.29	38.29	38.29	38.29	38.29	38.29	38.29
Contingencies (5%)	3.64	192.66	145.70	349.93	349.93	349.93	349.93	349.93	349.93	349.93	349.93	349.93	349.93	349.93	349.93	349.93
TOTAL OPERATING COST	3.63	4014.91	5563.99	7350.01	7351.58	7353.24	7354.98	7356.80	7356.80	7356.80	7356.80	7356.80	7356.80	7356.80	7356.80	7356.80
TOTAL CASH OUTFLOW	**50.27**	**4014.91**	**5587.99**	**7369.01**	**7375.58**	**7353.24**	**7397.98**	**7356.80**	**7380.80**	**7375.80**	**7380.80**	**7356.80**	**7399.80**	**7380.80**	**7356.80**	**7356.80**
NET CASH FLOW	**-50.27**	**81.30**	**528.42**	**781.48**	**776.71**	**796.38**	**755.19**	**792.82**	**771.49**	**774.69**	**771.49**	**792.82**	**753.36**	**768.82**	**795.49**	**805.69**
DISCOUNT FACTOR AT 21 % DR	1.00	0.83	0.68	0.56	0.47	0.39	0.32	0.26	0.22	0.18	0.15	0.12	0.10	0.08	0.07	0.06
DISCOUNTED CASH INFLOW	0.00	3385.11	4177.51	4600.95	3803.04	3141.68	2597.60	2145.80	1773.94	1466.27	1211.43	1000.77	827.55	683.75	564.95	470.16
DISCOUNTED CASH OUTFLOW	50.27	3317.92	3816.60	4159.81	3440.71	2834.67	2356.99	1937.04	1606.06	1326.91	1096.79	903.42	751.08	619.25	509.83	423.75
DISCOUNTED NCF AT 21%	-50.27	67.19	360.91	441.15	362.33	307.01	240.60	208.75	167.88	139.37	114.64	97.36	76.47	64.50	55.13	46.41
NPV AT 21%	**2699.41**															

APPENDIX 4.5: INCREMENTAL CASH FLOW PROJECTION

YEARS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NET CASH FLOW ZECC	(755.11)	372.77	1,063.15	2,093.77	2,059.71	2,029.46	2,063.84	2,086.14	2,049.28	2,080.19	2,002.34	2,086.14	2,059.91	2,102.72	2,082.72	2,197.67
NET CASH FLOW FOR TMS	(50.27)	81.30	528.42	781.48	776.71	796.38	755.19	792.82	771.49	774.69	771.49	792.82	761.65	777.11	803.78	813.98
INCREMENTAL NET CASHFLOW	(704.84)	291.47	534.73	1,312.28	1,283.00	1,233.08	1,308.65	1,293.32	1,277.78	1,305.49	1,230.84	1,293.31	1,298.25	1,325.60	1,278.93	1,383.69
DISCOUNT AT 21% RATE	1.00	0.83	0.68	0.56	0.47	0.39	0.32	0.26	0.22	0.18	0.15	0.12	0.10	0.08	0.07	0.06
INCREMENTAL NCF @ 21% DR	(704.84)	240.87	365.22	740.78	598.52	475.35	416.94	340.53	278.05	234.86	182.90	158.82	131.77	111.22	88.63	79.70
INCREMENTAL NPV@ 21% DR	**3,739.32**															

APPENDIX 4.7: STATA RESULTS FOR PROBIT REGRESSION OUTPUTS

Probit regression	Number of obs	=	175
	Wald chi2(13)	=	62.07
	Prob > chi2	=	0.0000
Log pseudolikelihood = -11.249184	Pseudo R2	=	0.9030

AdoptZECC	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
Gender	1.634345	.6426167	2.54	0.011	.3748394	2.89385
Age	-.0347962	.0281066	-1.24	0.216	-.0898842	.0202917
HHSize	-.326414	.1310144	-2.49	0.013	-.5831975	-.0696306
YrsEdu2	1.464869	.3676174	3.98	0.000	.7443524	2.185386
Marital	-.3864575	.4027139	-0.96	0.337	-1.175762	.4028473
GBO	1.656085	.7600316	2.18	0.029	.16645	3.145719
Extension	1.339175	.68459	1.96	0.050	-.0025973	2.680946
Location	.1874261	.9438962	0.20	0.843	-1.662576	2.037429
PerceivedCostZECC	-2.936343	1.06542	-2.76	0.006	-5.024528	-.848158
MonthlyIncomTomato	.0040041	.0020487	1.95	0.051	-.0000114	.0080195
Save	-1.316072	.5556276	-2.37	0.018	-2.405082	-.2270615
TypePersonAware	1.151424	.5338167	2.16	0.031	.1051626	2.197686
UsersTMS	-3.596869	1.480074	-2.43	0.015	-6.497761	-.695976
_cons	1.646924	2.244501	0.73	0.463	-2.752216	6.046064

APPENDIX 4.8 MARGINAL EFFECTS OUTPUTS

. mfx

Marginal effects after probit
y = Pr(AdoptZECC) (predict)
= .99595546

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
Gender*	.031591	.04499	0.70	0.483	-.056595	.119777	.485714
Age	-.0004163	.00066	-0.63	0.531	-.001719	.000886	43.1886
HHSize	-.0039056	.00671	-0.58	0.561	-.017057	.009245	9.89143
YrsEdu2	.0175273	.02991	0.59	0.558	-.0411	.076155	4.74857
Marital	-.004624	.00991	-0.47	0.641	-.024044	.014796	2.08571
GBO*	.0382024	.04571	0.84	0.403	-.051383	.127788	.531429
Extens~n*	.042745	.08937	0.48	0.632	-.132425	.217915	.702857
Location*	.0019081	.01042	0.18	0.855	-.018514	.02233	.16
Percei~C*	-.1876019	.13851	-1.35	0.176	-.459069	.083865	.4
Monthl~o	.0000479	.00008	0.62	0.537	-.000104	.0002	227.314
Save*	-.0145912	.02435	-0.60	0.549	-.062323	.033141	.64
TypePe~e*	.0268793	.0435	0.62	0.537	-.058387	.112145	.64
UsersTMS*	-.0405818	.0417	-0.97	0.330	-.122312	.041149	.748571

(*) dy/dx is for discrete change of dummy variable from 0 to 1