

**MODELING POST HARVEST LOGISTICS OPERATION OF
PEPPER: A CASE OF HALABA ZONE**

MSc. THESIS

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A CASE OF HALABA ZONE

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**A THESIS SUBMITTED TO THE
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This is to certify that the thesis entitled: **Modeling post-harvest logistics operation of pepper: a case of Halaba zone** submitted in partial fulfillment of the requirements for the degree of masters with specialization in Industrial engineering and logistics management, the graduate program of the department Industrial engineering, and has been carried out by the Id. No. of IELMW/0002/11 under our supervision. Therefore we recommend that the student has fulfilled the requirement and hence hereby can submit the thesis to the department.

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We, the undersigned, members of the board of examiners of the final open defense by Bereket Tadiwos have read and evaluated his thesis entitled “**Modeling post-harvest logistics operation of pepper: A case of Halaba zone**” and examined the candidate.

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I hereby declare that this MSc thesis report entitled “**Modeling post-harvest logistics operation of pepper: A case of Halaba zone**” is original work and has not been presented for a degree in any other university, and all sources of material used for this thesis / dissertation have been duly acknowledged.

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This MSc thesis has been submitted for examination with my approval as thesis advisor.

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ACRONYMS AND ABBREVIATION

Abbreviation	Stands for
AHP	Analytic Hierarchy Process
CSCMP	Council of Supply Chain Management Professionals
DC	Distribution Center
EC	Ethiopian Calendar
ETB	Ethiopian Birr
ESE	Ethiopian Spices Exporters
FSC	Food Supply Chain
FSCN	Food Supply Chain Network
MILP	Mixed Integer Linear Programming
PhD	Doctor of Philosophy
Pred	Prediction
SC	Supply Chain
SCM	Supply Chain Management
SNNPRG	South Nation Nationalities and People Regional Government
SCND	Supply Chain Network Design
MOMILP	Multi-Objective Mixed Integer Linear Programming
MINLP	Mixed Integer Non-Linear Programming
RPA	Rapid Market Appraisal
W	Warehouse
Z	Production Zone

ABSTRACT

Logistics Optimization models have been used extensively for reducing logistics costs and maximizing benefits. Those models are for enhancing the logistics chain. Post-harvest logistics operations are for agricultural logistics activity after harvest. This thesis concerns on agricultural sector post-harvest logistics operation of red pepper. The thesis was conducted on one of the Ethiopian pepper-producing area called Halaba Zone. Taking Halaba red pepper as a case study, the research attempted to analyze the existing logistics practices and distribution process of Halaba red pepper, to optimize the pepper logistics activities. Data were collected using a questionnaire, case study, observation, semi-structured interview, and document analysis. The research uses SPSS software for statistical data analysis, Minitab19 software for regression analysis, Excel spreadsheet for Pareto analysis and Excel QM for LP transportation optimization model. The analysis of existing supply chain management practices indicates the availability of poor practices during logistics activities. The poor practices in logistics activities had a direct effect on pepper price inflation. In order to show correlation between price of pepper and logistics activities regression analysis conducted. The regression analysis result shows a positive correlation between logistics activities cost and price of pepper. After regression analysis Pareto analysis conducted taking four logistics activities costs as parameters. The need to conduct Pareto analysis is to give priority for greater contributor of logistics cost. Based on Pareto analysis transportation cost found as the greater contributor cost among logistics activities. Therefore transportation model built .The built transportation model can save 18.5343% of 2019/20 transportation cost of Halaban pepper. This percentile means the built model worth of saving were around 1,611,555 ETB. Based on this finding it's possible to conclude that measures taken in logistics activities can give positive result in minimizing price of pepper.

Key word: Logistics Activities, Optimization Model, Supply Chain Management, Pepper

CHAPTER ONE: INTRODUCTION

1.1 Background and justification of the study

Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores .so that merchandise is produced and distributed in the right quantities, to the right locations, and at the right time, to minimize system-wide costs while satisfying service level requirements. Generally, a supply chain is characterized by a flow of materials from suppliers to customers and by a flow of information in the opposite direction. According to Papageorgiou (2009), a good distribution strategy is an optimal supply chain or distribution network that satisfies customer demand at a specified service level at the lowest cost. It considers customer location, demand, transport cost, warehouse and inventory management, cash flows, and many more key variables.

Many factors influence network design decisions, such as geographic shifts in production and consumption, market segmentation, new markets, customer service requirements, cost increases in energy, plant and equipment maintenance, labor, governmental regulation and deregulation, product proliferation, and reduced product life cycles. These aspects have contributed to growing demand uncertainty and resulted in a need for a robust and well-designed SCN (Melo et al., 2009). As the concern of this paper is on the supply chain network of red pepper, it's mandatory to know about red pepper property. Pepper is a crop of high value in the world next to the tomato. It is the most important vegetable, the most produced type of spice: flavoring to food while providing essential vitamins and minerals. It is a rich source of vitamin A and E. both hot and sweet peppers contain more vitamin C to prevent flu colds than any other vegetable crop (Boselad et al., 2000).

The color and flavor extracts from pepper are used in both the food and feed industries (Rubatzky et al., 1997). Red Pepper quality is expressed in terms of some factors and best pepper is not hot, red in color, clean pole, a lot of meat, and fewer seeds, less water succulent, no disease, and no contaminant. When we see literature in Scm Tsiakis et al. (2001) explained that, in order to survive in a competitive environment, a supply chain should minimize costs, inventories, and investments; and, maximize deliveries, profit, return on investment, customer service level, and production.

The main goals of the supply chain design and planning is to determine the optimal network and optimize the production, distribution and storage resources to satisfy efficiently the demand (Papageorgiou, 2009) and maximize its long-term economic performance (Chaabane et al., 2012). In conclusion, the optimization of the SC design and planning is a complex process; however it is crucial for an effective supply chain management

1.2 Problem statement

In Ethiopia, red pepper is cultivated in many parts of the country. Since the larger proportion of the pepper produced is for the market, it takes a significant share of the national income from commodity export. Even though the country cultivates pepper but its Share in the world was insignificant. The pepper sub-sector can be characterized as Under developed, unorganized, small scale and inefficient .One of Ethiopian potential pepper-producing areas is Halaba zone. Just like other Ethiopian pepper, Halaba pepper supply trend also has many poor practices that affect the price and quality of pepper. Based on interviews and preliminary observation difficulty in getting quality pepper at a fair price is the main complain of Halaba pepper consumers. Looking at the existing Halaba pepper supply trend to Addis Ababa, the pepper is supplied only from Halaba Zone capital Kulito town. But compared to the capital town of the Zone, there are other potential areas of the zone which will take less distance for transporting pepper to Addis Ababa. The researcher beliefs this issue can affect the price of Halaba pepper. Another preliminary observation point comes from Halaba zone big market day called Thursday market; based on observation much of the poor practices on Halaba pepper post-harvest logistics activities was during transportation, storage, packing, and loading unloading.

1.3 Objectives

1.3.1 General objectives

The general objective of this study is to model the post-harvest logistics operation of Halaba red pepper

1.3.2 Specific objectives

The specific objectives are the following:

- To analyze the existing logistics practice of Halaba red pepper

- To analyze the existing distribution process of Halaba red pepper
- To propose an optimal model for the Halaba pepper post- harvest logistics activities.

1.4 Research questions

The following research questions addressed in this research paper

- What do the existing logistics and supply chain practice of red pepper look like?
- What do the distributions processes of Halaba red pepper look like?
- How to optimize post- harvest logistics activities of Halaba red pepper?

1.5 The scope of the research

The scope of this research paper is on post-harvest logistics only. It deals with Halaban pepper: focusing on pepper supply network channel to the central market of the country Addis Ababa. The research uses an optimization model and does not model every detail: it focuses only on the problem areas

1.6 Significance

This study has several benefits and beneficiaries. Some contributions are: it points out the things that make the pepper supply chain inefficient. The beneficiaries are the case area producer& distribution stakeholder. They can overcome challenges related to the supply chain of pepper. Also, it helps researchers who need to study further. They can use it as a starting point

1.7 Research organization

This thesis organized into five chapters. Chapter one begins with the background and justification of the research. It contains a statement of the problem, objective, scope, and significance of the study. Chapter Two is a literature review that discusses fundamental concepts of supply chain and related researches that had been undergone earlier. The gaps and similarities were also discussed in the chapter. Chapter Three is the research methodology that contains the research approach, data source, method of data collection, and analysis. The fourth chapter deals with results and discussion it contains the analysis, model formulation, verification, and validation. Finally, the conclusion and recommendation are addressed in Chapter Five.

CHAPTER TWO: LITERATURE REVIEW

2.1 Supply chain management

The supply chain management profession has continued to change and evolve to fit the needs of the growing global supply chain. With the supply chain covering a broad range of disciplines the definition of what is a supply chain can be unclear. Often times SCM can be confused with the term logistics management. So council of supply chain management professionals (CSCMP) created official definitions for the following terms.

Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners; which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management with in and across companies. Supply Chain Management includes all of the logistics management activities and manufacturing processes and activities with and across marketing, sales, product design, and finance and information technology (CSCMP, 2020).

Logistics Management is that part of SCM that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customer's requirements.

Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, material handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers. To varying degrees, the logistics function also includes sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service. It is involved in all level of planning and execution-strategic, operational and tactical (CSCMP, 2020).

Logistics management is an integrating function, which coordinates and optimizes all logistics activities, as well as integrates logistics activities with other functions including marketing, sales, manufacturing, finance, and information technology (CSCMP, 2020).

2.2 Literature review of research on supply chain

Optimization of supply chain network design and planning under recent trends was research by Carla (2016). The researcher used a mixed integer linear programming model for the design and planning of a food SCN, considering demand uncertainty and environmental impacts. The model objective is maximizing annual profit, minimizing the environmental impacts and minimizing the SCN lead-time. The result in the work provides the location and size capacity of the SCN entities, integrating transportation mode selection.

In the research literature review concerning the SCN design and planning fundamentals as well as the influence of uncertainty scenarios in this process are analyzed. Also concepts regarding sustainability and environmental issues; More specifically, concepts such as green supply chains and sustainable supply chain management are dealt .In conclusion, the work presents the theoretical concepts regarding uncertainties and environmental issues influencing the SCN design and planning. Also describes the main characteristics of food supply chains. Finally, this dissertation comes up with a mathematical model that integrates the aspects described above, which is then applied to a food SCN.

(Keizer2015), logistics network design & control; managing product quality in a blooming sector. The overall research objective of the research is to develop quantitative modeling approaches that support the (re)design of a perishable product logistics network for supply and demand driven supply chains. In the work researcher used three modeling techniques such as MILP, simulation & hybrid (optimization& simulation).The thesis focused on three main supply chain management (SCM) themes and subsequent SCM issues such as issues related to decision problems, which comprises network design and network control. The second theme is related to context factors, which comprises supply and demand uncertainty, perishability, and product & market differentiation. The third theme is related to objectives, which comprises efficiency, responsiveness and product quality. For optimal and robust logistics network design a case study in the European potted plant supply chain network was conducted and mixed integer linear programming (MILP) model was developed to solve the location-allocation problem.

For network control decision problems simulation modeling technique have been used and also hybrid simulation and optimization technique used to design a logistics network for distributing perishable products. The approach is developed to enable the inclusion of product quality decay and product quality uncertainty in network design. In conclusion as the work is a PhD research it encompass a broad issues in detail and tried to cover complex supplied chain design & control issues in different perspective which makes the research effective & helpful.

Wouda et al. (2002), in this research A MILP model was presented to optimize the SCN of Nutricia Dairy & Drinks Group, the company had approximately 300 different dairy products such as Yogurt, cheese, butter, desserts and milk. The objective of the model is the minimization of production and transportation costs and to determine the optimal number of plants, their locations and the allocation of the product portfolio to these plants, regarding alternative strategies.

Ahumada and Villalobos, (2011) presented a mixed integer-programming model for production and distribution tactical planning of fresh produces. This model maximizes revenues. The model was applied to a hypothetical large fresh product grower in northwestern Mexico, who's produced two crops – tomatoes and peppers. It is important to refer that this model takes into account the perishability in the following ways.

As a loss function in its objective function and, as a constraint for the storage activities. Later Ahumada et al. (2012) extended the work introduced by Ahumada and Villalobos.(2011) by adding uncertainties due to the variability of weather and demand. The objective function corresponds to the maximization of total revenue for the producers. The model proposed was a two-stage stochastic program to achieve planting and distribution plans and was applied to the same case study of Ahumada and Villalobos. (2011). this approach for food supply chain allows products with the right quality and shelf-life reach the right customer.

2.3 Supply chain design and analysis

Dong (2001): has categorized modeling approaches in SCM into five broad classes and these are classified as follows:

- A. Supply Chain Network Design Method: - This method determines the location of production, stocking, and sourcing facilities, and channels the products take through them.
- B. MIP Optimization Modeling:-vehicle routing and scheduling, facility location and sizing, shipment routing and scheduling, freight consolidation and transportation mode selection fall into the MIP (Mixed- Integer Programming) class.
- C. Stochastic Programming and Robust Optimization Methods: - deals with a class of optimization models and algorithms in which some of the data may be subject to significant uncertainty.
- D. Heuristic Methods: Heuristic is another important class of methods for generating supply chain alternatives and decisions. This method generally works only for solving linear and some integer-based models, commonly used in strategic levels of planning.
- E. Simulation Based Methods: - This method evaluates the effectiveness of a pre specified policy before developing new ones.

2.4 Literature review of Ethiopian supply chain management researches

Ethiopian products supply chain is very traditional and not well managed. It is performed simply by traditions. Product quality degradation, food spoilage, price increase and overall customer dissatisfaction usually happens due to distribution problem in the SC.

In different time, different researches conducted on Ethiopian products supply chain. Mostly conducted researches are on performance improvement; few are on network design.

Supply chain network design and analysis using simulation technique is thesis work by Tewodros (2018.) taking kojji food processing company as case company. In his work he focused on how supply chain system performance can be improved by using simulation analysis techniques. The aim of the research is mostly on identifying the existing supply chain system problems and tries to analyze the performance by using arena simulation software. The research does not model every detail of the supply chain but rather focuses on the problem areas.

Another thesis work in Ethiopian supply chain is by (Desalegne wubeti, 2018) by the topic of performance optimization of supply chain management systems: a case of Alle Bejimla. His study focused on the assessment of the existing supply chain problems in Alle Bejimla at each level of supply chain and finding solution by developing a performance Optimization of SCM system. The study is based on descriptive qualitative and quantitative methods. The limitation of this study is its simply describing but did not obtain the reliable and useful research findings.

Selamawit (2016) proposed production modeling to improve internal supply chain of large scale poultry farms. she developed an excel flock projection data base and simulation model which allow for analysis of the processes and calculations of effective use of each resource, easily determine and quantify the required facility, enable communication horizontally and vertically throughout the internal supply chain.

Mieraf (2016) Supply chain performance improvement model in Ethiopia meat processing industry. This study was conducted mainly to evaluate supply chain performance of meat processing companies in Ethiopia. It works on determining the key indicators of companies' performance measurement by using the analytic hierarchy process (AHP) to improve supply chain performance for industries. The study uses the concept of decision making levels and supply chain macro processes as its approach to the study of the supply chain performance measurement. The whole finding is the analysis of an overall supply chain performance from three supply chain macro processes; supplier relationship management, internal supply chain management and customer relationship management based on strategic, tactical and operational decision making levels.

2.5 Literature reviews of Literature researches conducted on Ethiopian red pepper

Most research conducted on Ethiopian red pepper is on finding market channel. Determinants of pepper market supply among small holder Farmer in Wonberma district, West Gojjam Zone of Amhara region (Gizachew et.al, 2019). The aim of the study was to identify determinants of quantity of pepper supply to the market among small holder farmers in Wonberma district.

Another study is market chain analysis of red pepper: the case of Abeshge district, Guaragie Zone, South Ethiopia (Dessie et.al, 2017). The major objective of the study was to investigate red pepper market chain in Abeshge district. And worked to identify the actors and their functions in the market chains of red pepper and map the marketing channels of red pepper. And the researchers conducted further research to undertake red pepper value chain analysis and examine the factors that affect the supply of red pepper (Dessie et.al, 2018)

Analysis of red pepper marketing; the case of Halaba and Silte in SNNPRG (Rehima, 2006).The researcher focused on marketing issue and other social factors that affect the supply of Halaba red pepper. The research attempts to examine red pepper marketing in Halaba and Silte with the specific objectives of identifying marketing channels, and the role and linkage of marketing agents, quantifying costs and margins for key marketing channels, identifying factors affecting volume of pepper supply in Halaba and Silte and examining integration between regional markets and the terminal market. Red pepper marketing channels, and the role and linkage of marketing agents has been evaluated using structure, conduct and performance approach. This study also attempts to investigate the performance of pepper marketing channel by analyzing marketing costs and margins.

2.6 Gaps of reviewed literature

From the literature review carried out on FSCN design and planning; most of the researches done are generic facility location allocation models and many are not addressing FSC in particular. The existing literature regarding perishability and analytic approaches are mostly related to inventory management. Many of the researches founded integrate production and distribution decisions and not SCN design. In Ethiopia also, mostly conducted researches are on performance improvement of product.

Table 2.1 Literature review summary table

No	Author	Method	Title	Finding and gap
1	(Vahab et al.,2019)	Uses a stochastic Mixed Integer Linear Programming	Sustainable Supply Chain Design using Two-stage Stochastic Modeling under Demand Uncertainty	The model designed to make decisions about the number and location of collection centers. The gap is the model is hard in achieving optimal solution in real-world problems
2	(Turan et al.,2010)	MILP	A multi-objective mixed integer programming Model for multi echelon supply chain network Design and optimization	The author developed a model that determines from which suppliers, manufacturers, DCs and how much amounts transported to answer customers demand. The gap is the authors do not consider cost and demand uncertainty. Also there is gap in effectiveness of the solution methodology.
3	(Humberto et al.,2015)	Optimization model is used	Design of a logistic platform through the optimization of Agricultural distribution Networks in panama	Developed a mathematical model that depicts both the behavior of the agricultural SC and analyzed the transportation equipment used in the logistic chain in order to obtain an optimal transportation policy of agricultural products from the main production center to the different consumption points
4	(Pawel et al.,2017)	It used computer tools based on graph theory	Optimization of the post logistics network and location of the local distribution selected area of the Lublin province	Optimization of existing logistics network takes placed using computer oriented simulations and found a new location of the local distribution center that minimize transport cost for delivery of postal in selected area of Lublin province.

5	(Chang et al.,2015)	Uses LP	Cold Chain Logistics Distribution Network Planning Subjected to Cost Constraints	This paper analyzes the cold chain logistics distribution network planning which is Subjected to cost constraints, and establishes a cold chain logistics distribution network Model by minimizing the total operation cost. The gap of the research is in the practice, cold chain providers are many. They also provide various products in the same time: but the author proposed a model for single supplier and one product type.
6	(Zhu et al.,2014)	Uses simulation model	A Flexsim-based Optimization for the Operation Process of Cold Chain Logistics Distribution Centre	This paper analyzes a Fruits and vegetables Cold-Chain Logistics Distribution Centre and collects the fundamental Data, then builds the simulation model for the operation process of the Cold-Chain Logistics Distribution Centre By using Flexsim software. The gap is Analytical method can't analyze and optimize such system completely.
7	(Petridis et al.,2015)	It used MILP model	A model for the optimal design of a supply chain Network driven by stochastic fluctuations	This article Proves that the producer may benefit through better outlay in the form of higher sale prices with lowered optimized production costs only through a suitable selective choice of Producers whose production cost probability density function abide a Pareto distribution.

8	(Nguyen et al., 2019)	It used Linear Programming Optimization Model	Optimization Model for Fresh Fruit Supply Chains: Case-Study of Dragon Fruit in Vietnam	A deterministic model is proposed in this paper to assist dragon fruit farmers with their decision making on crop allocation for different species of dragon fruits. The gap of this research is the model does not deal with network decisions.
9	(Okunade et al.,2020)	LP model was used	A distribution network design for fast-moving Consumer goods	This research is a real-life case study in Southwestern Nigeria. The author found that distribution through intermediaries gives a better solution than routing option with direct shipment.
10	(Patricia et al.,2020)	It used (AHP)	Food SC Optimization modeling in the Rice Crop Post Harvesting in the Philippines: An Agro ecological Approach in Food Sustainability	The researchers identified that the key factor to minimize the losses in the post-harvesting process in order for the farmers to maximize their profit is: Temperature Management and Moisture Content. The gap of this research is the model does not deal with network decisions.
11	(Rehima, 2006)	Tobit and Heckman two Stage econometric models	Analysis of red pepper marketing: the case of Halaba and Silte in SNNPRS of Ethiopia	This research work is on marketing issue and it strives to identify marketing channels, the role and linkage of marketing agents; quantifying costs and margins for key marketing channels.

CHAPTER THREE: METHODOLOGY

3.1 Research design and approach

The research design is significant for providing an appropriate solution. It is important to set up guide lines, to make the studies throughout the system towards its objective. Research design is involved in many correlation issues to obtain important and relevant information that makes a decision in easy ways (Stefan et al., 2005). To achieve the objective of this study; a descriptive-research approach which used both qualitative and quantitative research approaches were employed. According to Fauzi (2018), the qualitative analysis or approach was employed to answer questions about the complex nature of an existing phenomenon, having the purpose of describing and understanding it from the view of points of the participants or target groups. Quantitative research is primarily focused on the numeric analysis of data (Shekhar, 2019).

Under this thesis research, Halaba pepper was selected as a case study. And it has done preliminary observation on the practice of pepper post-harvest logistics activity. Subsequently, an intensive literature survey was conducted to understand the existing concepts and methods. Then relevant data were collected from the case area using questionnaires, semi-structured interviews, observation, case study, and document analysis. Data collected from different sources and methods need specific data analysis methods and tools to process and get insights from them. Therefore regression analysis was conducted to show correlation, and then Pareto analysis was conducted to find a greater contributor to the price of pepper and based on result transportation model developed using linear programming.

3.2 Data type and source

Both primary and secondary data were used for the study. Primarily data were those which were collected a fresh and for the first time and they are believed to be original in character VO (2017). Primary data was collected to provide information regarding a specific topic and secondary data are data previously collected and analyzed that includes documents analyzed.

3.2.1 Primary data

The primary data was collected mainly using questionnaires and case study. In addition observation and semi-structured interview were also used to find some primary data.

The questionnaire, interview, and observation were to collect data that was used to analyze the existing logistics and supply chain management practice of red pepper. It focused on the size of output, packing and material handling trends, loading and unloading trends, storage trend& costs, transportation trend &costs, causes of losses, price of sell, and other SCM related data. Data sources are Halaban pepper supply chain stake holders: such as producers, traders, processors, consumers, and storage service providers, and others.

3.2.2 Secondary data

The secondary data was collected through document analysis. The data was obtained from Halaba zone agricultural office, from the Halaba zone trade and industry office, from Central Statistical Authority (CSA), and from published and unpublished documents.

3.3 Method of data collection

3.3.1 Questionnaires

Independent questionnaires were designed for producers and pepper traders: involved in the supply chain channel between the Halaba zone and Addis Ababa. Before data collection, the questionnaires were pre-tested. This led to further revision of these lists to make sure that important issues had not been left out.

3.3.2 Case study

A case study was used to collect data for Regression Analysis, Pareto Analysis, and optimization model development

3.3.3 Observation

Observation helps to identify and guide relationships with informants, to learn how things are organized, to learn what constitutes appropriate question, how to ask them and which question may best help to answer the research questions (Kawulich, 2012). The main benefits of observation are reduced wrong rumors' without requesting others. In this research an observation method was used to check and control validity and reliability of data collected for analyzing existing logistics and supply chain practice of Halaba red pepper.so that case area market areas, storage places, transportation means, loading-unloading &packing trends and other key factors observed.

3.3.4 Semi-structured interviews

Face to face interview method is preferred due to its flexibility and ability to provide new ideas on the subject. Moreover, it enables to obtain in-depth information about participants' thought, beliefs, knowledge, reasoning, motivation, and feeling about the issue under study (CR, 2004).

Consumers of Halaba pepper are large in number. It requires more time and budget to address all consumers' perceptions. Due to time and budget constraints: A semi-structured interview was selected to collect data from the consumer perspective. Therefore 10 Semi-structured interviews were conducted randomly. Participants are Halaba pepper consumers. In number, they are five from Halaba, three from Hawassa, and two from Addis Ababa.

3.3.5 Document analysis

Document analysis is a systematic procedure for reviewing or evaluating documents both printed and electronic (computer based and internet transmitted) material. Like other analytical methods in qualitative research, document analysis requires that data be examined and interpreted in order to elicit meaning and gain understanding. Document analysis is often used in combination with other qualitative research methods as a means of triangulation (Bowen, 2009). In this research the following data were collected using document analysis: Collected data were about factors affecting market supply, yearly production output, weekly pepper market price, pepper carriage distances, production districts location, production output, and capacity utilization.

3.4 Sample design

3.4.1 The target population

The research has two target populations. They are Halaba pepper producers, and traders and processors that exist in the supply chain channel between Halaba zone and Addis Ababa. Halaba zone has 73 peasant administrations. Each peasant administration possesses on average 145 pepper-producing farmers. For this research 10 peasant administrations were selected randomly for collecting data through questionnaire. $10 \times 145 = 1450$ becomes target population of Halaba pepper producers.

The second target populations are Halaban pepper traders and processors. According to data from Halaba zone trade and industry office: in the supply chain channel of red pepper between Halaba zone and central market of the country Addis Ababa, on average there are 1050 traders and processors.

3.4.2 Sampling technique

The sample size analysis was for data collection through questionnaire. Two independent questionnaires were prepared for collecting data from pepper producers, traders, and processors: considering the supply chain channel from the Halaba zone to the central market of the country Addis Ababa. Simple random sampling was used because the logic behind simple random sampling removes bias from the selection procedure and gives representative samples. As the stakeholders of the red pepper supply chain were large: Cochran (1977) formula used to determine sample size

$$n_0 = \frac{z^2 pq}{e^2}$$

Where: n_0 = the sample size for infinite population

In this research 95% confidence level 10% margin of error (e) considered

z = the selected critical value of desired confidence level, from normal distribution table
 $z=1.96$

p = the estimated variability proportion of an attribute measure in the population (to categorize the population into two classes. p taken 0.5 that indicates the maximum variability (heterogeneousness) in a population, it is often used in determining a more conservative sample size

$$q = 1 - p = 1 - 0.5 = 0.5$$

Sample size of Halaban pepper producers

Computing sample size for producers of red pepper using Cochran (1977) formula gives

$$n_0 = \frac{z^2 pq}{e^2} = \frac{1.96^2 * 0.5 * 0.5}{0.1^2} = 96.04$$

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}} = \frac{96.04}{1 + \frac{96.04 - 1}{1450}} = 90$$

Therefore sample size for questioner of producers becomes n=90

Sample size of Halaban pepper traders and processors

The sample size population computed

The sample size for finite population

$$n = \frac{n_0}{1 + \frac{(n_0-1)}{N}}$$

$$n_0 = \frac{z^2pq}{e^2} = \frac{1.96^2 * 0.5 * 0.5}{0.1^2} = 96.04$$

$$n = \frac{n_0}{1 + \frac{(n_0-1)}{N}} = \frac{96.04}{1 + \frac{96.04-1}{1050}} = 88$$

Therefore sample size for traders and processors in the supply channel for collecting data through questionnaire becomes n=88. An attempt was made to select representatives by incorporating licensed and un-licensed traders shown in the table 3.1 below

Table 3.1: Sample size of traders and processors

Traders	Markets				Total
	Halaba kulito	Halaba Besheno	Halaba Guba	Addis Ababa (Merkato)	
Urban wholesaler				7	7
Reg. wholesaler	6	2	2		10
Urban retailer	12	2	2	6	22
Farmer trader	8	5	5		18
Urban assembler	8	4	6		18
Balitina shops	6	2	2	3	13
Total	40	15	17	16	88

3.5 Method of data analysis and presentation

3.5.1 Pareto analysis

It is referred to as the 80/20 rule, a nomenclature which has popularized a complex economic concept introduced by Vilfredo Pareto, a nineteenth-century Italian economist. The underlying concept is that the majority of problems (roughly 80%) are often caused by a small number of the sources roughly 20 % (Powell et al., 2015)

3.5.2 Regression analysis

Regression analysis is a tool used to analyze relationship between independent and

dependent variables. The key benefit of using regression analysis is it can indicate the relative strength of different independent variables effect on dependent variable. Therefore it helps to make predictions (Sarstedt, 2014).

The step to construct regression is as follows first, the raw data was filled in Minitab 19. Then their correlation was tested. The correlation coefficient can range in value from -1 to $+1$. The larger the absolute value of the coefficient, the stronger the relationship between the variables. In the Pearson correlation, an absolute value of 1 indicates a perfect linear relationship. A correlation close to 0 indicates no linear relationship between the variables.

3.5.3 Linear programming

Linear programming is the name of a branch of applied mathematics that deals with solving optimization problems of a particular form. Linear programming problems consist of a linear cost function (consisting of a certain number of variables) which is to be minimized or maximized subject to a certain number of constraints. The constraints are linear inequalities of the variables used in the cost function. The cost function is also sometimes called the objective function. Linear programming is closely related to linear algebra; the most noticeable difference is that linear programming often uses inequalities in the problem statement rather than equalities (Schulze, 1998).

3.5.4 Validity and reliability

validity is a tool commonly employed to ensure that the measures used are appropriate for the concepts that are being tested (sekaran, 2003).As for the validity, Zikmund (1997) points out that validity is the ability of an instrument to measure the main concepts and main issues that plan to be measured. Silverman (1997) addresses “a central dimension of validity involves the correspondence between a theoretical paradigm and the observations made by the researcher” (p.213).

Reliability is defined as “the degree to which the finding is independent of accidental circumstances of the research” (Kirk and Miller, 1986, p. 20). It means that other people may obtain the same finding if they go through the same research process. In this research an observation method was used to check and control validity and reliability of data collected for analyzing existing logistics and supply chain practice of Halaba red pepper.

CHAPTER FOUR: RESULT AND DISCUSSION

This chapter deals with the findings, descriptive statistics, and optimization model: on the supply chain network of Halaba red pepper. Especially it concerns on supply chain channel between Halaba Kulito and the central market of the country called Addis Ababa. It deals with the analysis of existing post-harvest logistics operations. It also deals with finding a new distribution model through optimization.

4.1 Overview of case area

Halaba zone has 3 Woreda's and 73 pepper-producing Peasant administrations. Peasant administrations are clustered into 11 pepper-producing districts. Each district includes 3-8 Peasant administrations.

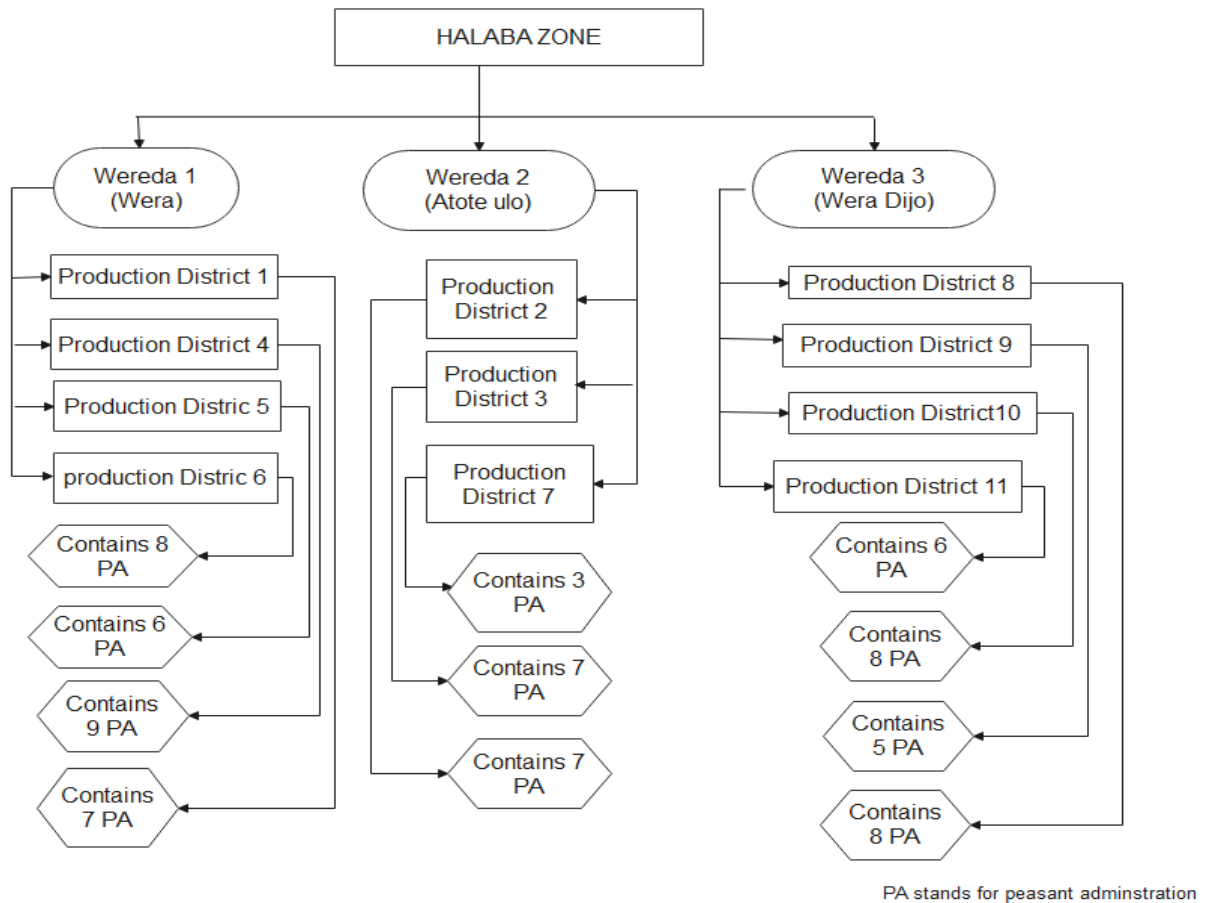


Figure 4.1: Halaba Zone Pepper Production District Structure

4.1.1 Halaba pepper supply chain map

The figure below shows Halaba pepper supply from production area to end consumer. It shows the logistics activities involved from production farm to export carriage through the capital city of the country Addis Ababa. Ethiopian spices including red pepper are exported by Ethiopian spice Agency.

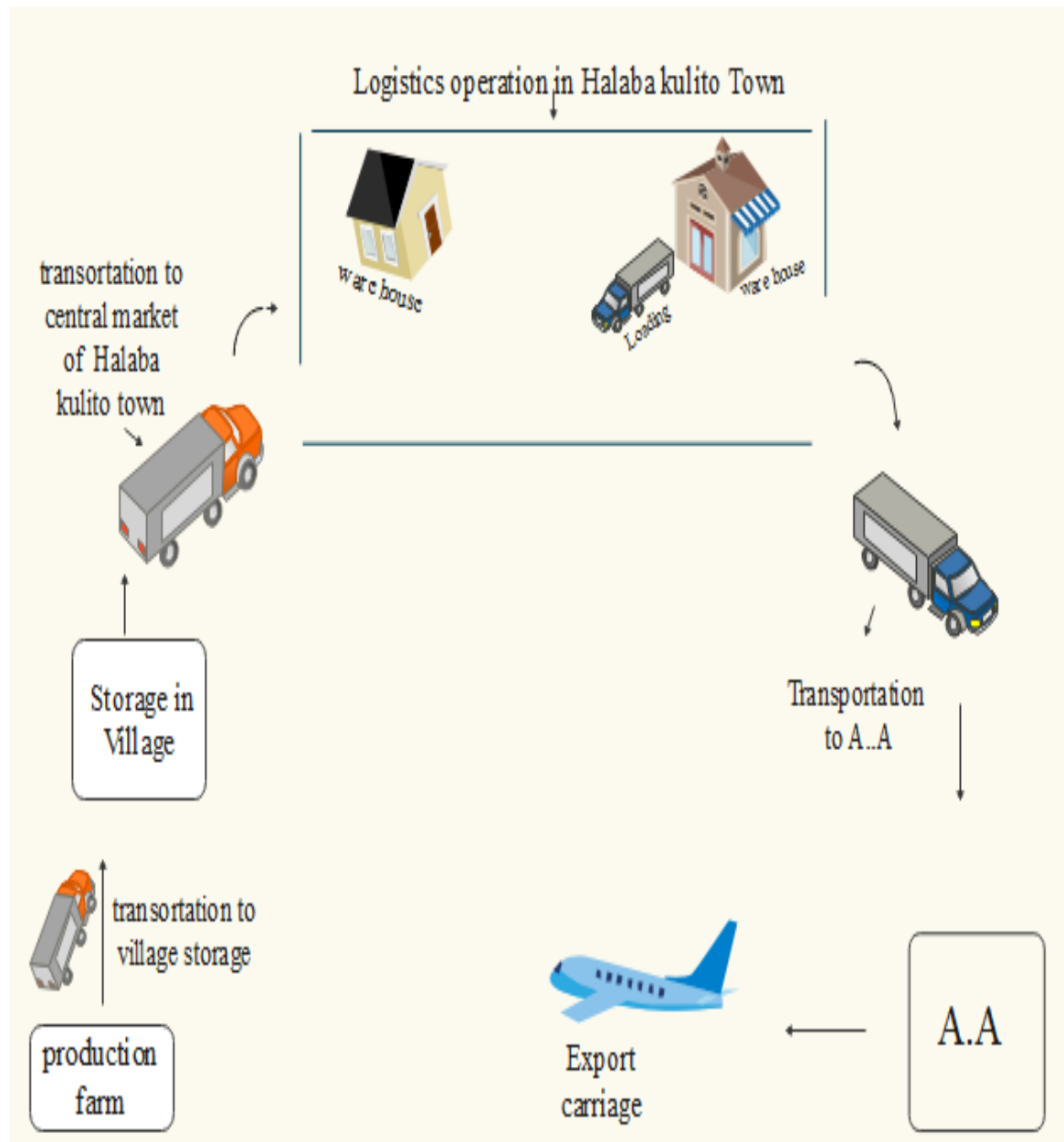


Figure 4.2: Halaba pepper supply chain map

4.1.2 Halaba pepper supply chain channels, participants roles and linkages

This thesis focuses on Halaba pepper supply route to Addis Ababa and the shaded route shows participant of Halaba pepper supply route to Addis Ababa.

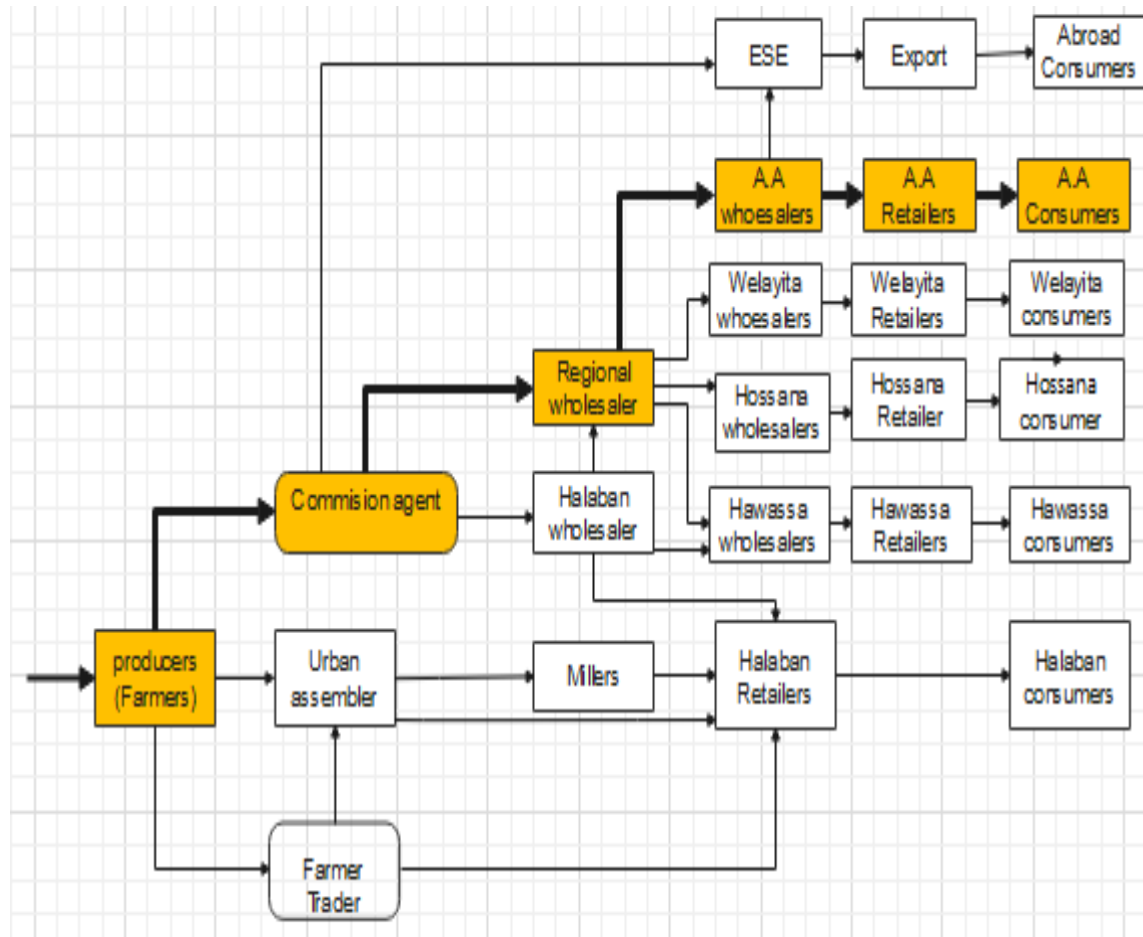


Figure 4.3: Supply chain channel of Halaban pepper

Farmer trader/village assemblers: Farmer traders/village assemblers are farmers or part time traders in the assembly markets who collect pepper from farmers in village markets for the purpose of reselling it to consumers or regional wholesalers in regional market. They use their financial resources and their local knowledge to bulk pepper from the surrounding area.

Urban assembler: are those that buy pepper from farmers in small village markets to resell to regional wholesaler or urban assemblers who have large capital. The majority are female who have hand-weighing scale with maximum measuring capacity of 50 kg.

Brokers: Brokers are agents who work for a commission on behalf of other participants. They specialized in bringing the buyers and sellers together.

Wholesalers: Wholesalers are someone who buys large quantities of goods, and resells to merchants rather than to the ultimate customers. Wholesalers are the major actors in the marketing channels.

Regional wholesalers are those who reside in woreda town and purchase pepper either through broker or directly from farmer or farmer trader or urban assemblers or commission agents. They re-sack it to big sack “teka” or they may directly purchase it with “teka” and supply the pepper to the terminal market (Addis Ababa) and other deficit markets.

Urban wholesalers: Urban wholesalers are terminal market wholesalers who reside in terminal market (Addis Ababa) and travel to regional market to buy pepper through the service of a broker or directly from farmers or regional wholesalers or urban assemblers. Wholesalers in the terminal market purchase pepper in bulk from regional wholesalers in terminal market and sell it to retailers. They also serve as retailers in their local area and to a large extent also supply pepper to ‘balitina’ shops and millers.

Urban retailers: Retailers are persons or company that sells commodity to end users. The majority of pepper retailers in the terminal market is characterized by, no stores and shops, often trading whole pepper purchased from wholesalers (regional or urban) or farmer traders or urban assemblers or farmers. There are no retailers in regional markets therefore rural consumers can buy from urban assembler or farmer traders or farmers.

Balitina shops: ‘Balitina’ shops play major role in pepper trading and processing. They buy whole pepper from rural and urban wholesalers. They process and sell pepper to consumers and to retailers in Addis Ababa. Some of ‘Balitina’ shops have agents in other parts of the country and sell through these agents for domestic consumption and export market.

Millers: Millers are owners of pepper mills who process the pepper. Usually they buy low quality pepper at low price directly from regional and urban wholesalers and use low quality spice to resell their processed product to consumers or retailers. In addition to this, they provide grinding services to ‘Balitina’ shops, wholesalers, and consumers.

4.2 Document analysis

4.2.1 Production report of Pepper

Depending on two peppers production seasons of the year, production report of peppers are two. They are production report of meher which is for the main production season. and production report of Belg.

A. Production report of Meher

Meher is the main season of crop production. Any temporary crop harvested between the months of September and February is considered as Meher season crop: in most cases, Meher crops are planted during the major rainy season.

Table 4.1: Meher production report of Halaba pepper; Source CSA (2015-2021)

Year of production	Total cultivated land in hectare	Production/ hectare	Total production in Quintal
2008 E.C (2015/16)	6251	17	106,275
2009 E.C (2016/17)	6320	19	120,088
2010 E.C (2017/18)	NA	NA	NA
2011 E.C (2018/2019)	NA	NA	NA
2012 E.C (2019/20)	5808.47	19.87	115,434.86
2013 E.C (2020/21)	6132.88	19.93	122,255.99

NA: Means Not Available

From the above table the production report for 2010 and 2011 E.C is not available but it is available Halaba Agricultural Office.

Table 4.2: Meher production report of 2010 & 2011 E. C Halaba pepper

(Source: Halaba Zone Agricultural Office (2017-2019))

Year of production	Total cultivated land in hectare	Production/ hectare	Total production in Quintal
2010 E.C (2017/18)	6127	21	128,675
2011 E.C (2018/2019)	5794	18	104,292

B. Production report of Belg

Belg Season Crop is any temporary crop harvested between the months' March and August (Pagume). In most case crops those planted during the short rainy season considered to be Belg Season Crop (CSA, 2021)

Table 4.3: Production report of pepper in Belg 2012

Year of production	Total cultivated land in hectare	Production/ hectare	Total production in Quintal
2012 E.C (2019/20)	5007	17	85,120

Source: Halaba zone agricultural office (2019/20)

C. Production report per each production district

This production report is the sum of the two pepper production seasons output for each production district.

Table 4.4: Total production per district of Halaba Zone

Production District (D)	Total quantity of pepper produced in quintals of 2012 E.C (Meher + Belg)
Production District 1	19448
Production District 2	21869
Production District 3	17529
Production District 4	16800
Production District 5	15780
Production District 6	22394
Production District 7	11735
Production District 8	20821
Production District 9	23253
Production District 10	16546
Production District 11	14379
Total	200,554

Source: Halaba zone agricultural office (2019/20)

4.3 Questionnaires data analysis

The questionnaires validated using Pearson correlation and the process of validation was as follows. First, the data was transferred from the questionnaire to SPSS Software. Then a validity test using Pearson correlation was conducted. In the process of validation, obtained value of Pearson correlation compared with the critical value for Pearson correlation coefficient. If the obtained value of Pearson correlation is greater than the critical value in the table, it means the questionnaire is valid. Therefore, this researches questionnaire was valid; because the obtained value of Pearson correlation was greater than the table value.

4.3.1 Suppliers questionnaire analysis

From 90 distributed questionnaires to farmers 18 questionnaires were missed. Generally from questionnaire about 80% of questions responded.

A. Farmer’s perception on transportation and material handling trend

As shown below in the bar chart, 52.86% of farmers encounter difficulty in obtaining proper material handling equipment for transporting pepper. 47.14% lack proper transporting means of pepper. Regarding packing material as shown below in the pie chart; 44.29% uses plastic sacks (Madaberya) and the rest uses sisal sack (Teka), Baskets, and other traditional means of material handling.

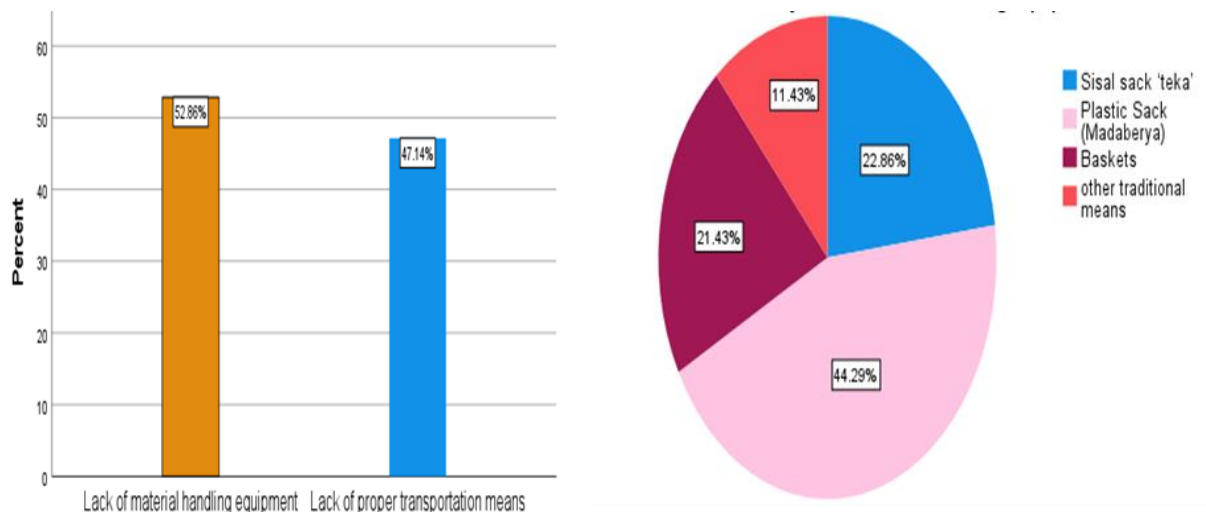


Figure 4.4 a) Common Problems of Pepper Transportation

b) Material Handling Equipment's

Regarding transportation as shown below in the pie chart only 18.31 % used cars for transporting pepper. The remaining uses pack animal, animal cart, and head back loading. 83.33% of Farmers responded availability of pepper loss during transportation. Such losses include heat damage caused by exposure to direct sunlight, decay of pepper caused by exposure to rainfall, content loss due to cracking of pepper through stacking during the carriage.

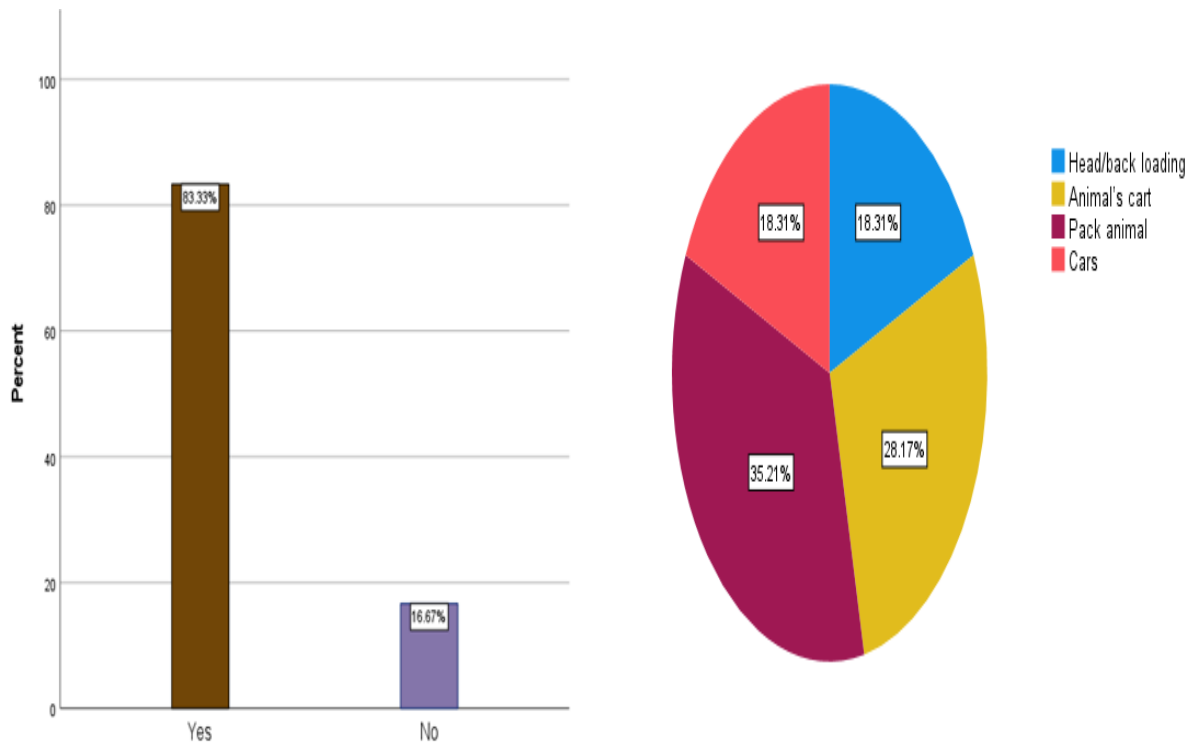


Figure 4.5 a) Loss during pepper transportation

b) Pepper transporting means of producers

B. Farmer’s perception on storage

Farmers’ storage condition after production is shown below in charts. As shown below in the pie chart, 75% of farmers store pepper after production. Regarding storage duration after production: which is shown in Bar chart below 27.78% stores below 1 month and 20.83% above 6 months: remaining stores 1- 6 months.

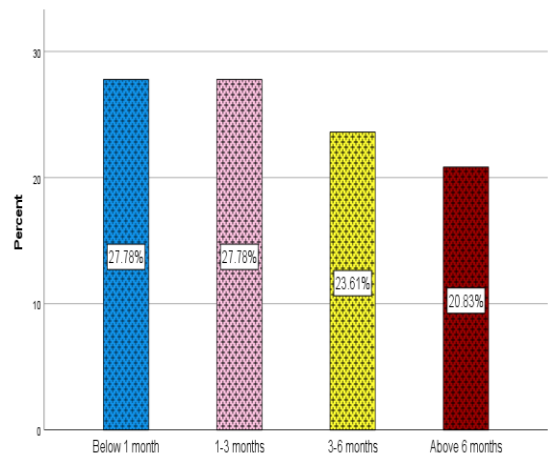
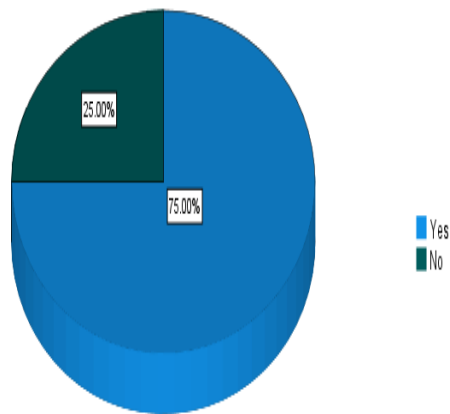


Figure 4.6 a) Storage condition after production

b) Producers storage duration of pepper

The common storage place preferred by farmers was ‘GOTERA’: almost half of the respondents (44.44%) stores pepper after production by placing in-store (GOTERA).

Common storage problems faced by farmers are shown in pie chart (Figure b). vulnerability to heat, vulnerability to moisture, and vulnerability to insect are among problems farmers encounter during storage

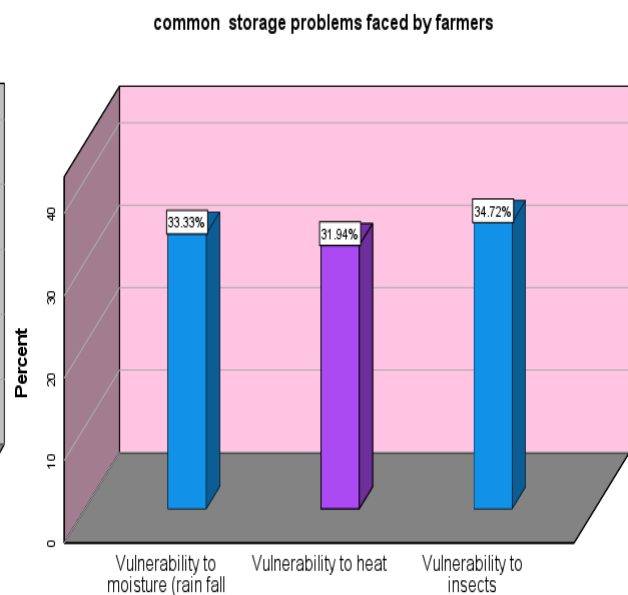
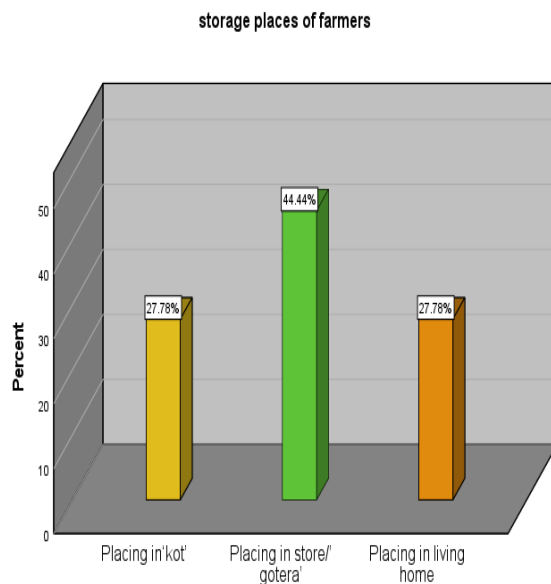


Figure 4.7 a) Producers storage places

b) Common storage problems of

Producers

4.3.2 Processors (traders)

A. Trader’s transportation & material handling trend

Majority of traders 43.84% uses vehicle(cars) for transporting pepper, 31.51% of traders uses animal cart,13.70% of traders uses pack animal, 31.51% of traders uses animal cart, and 10.96% of traders uses head back loading

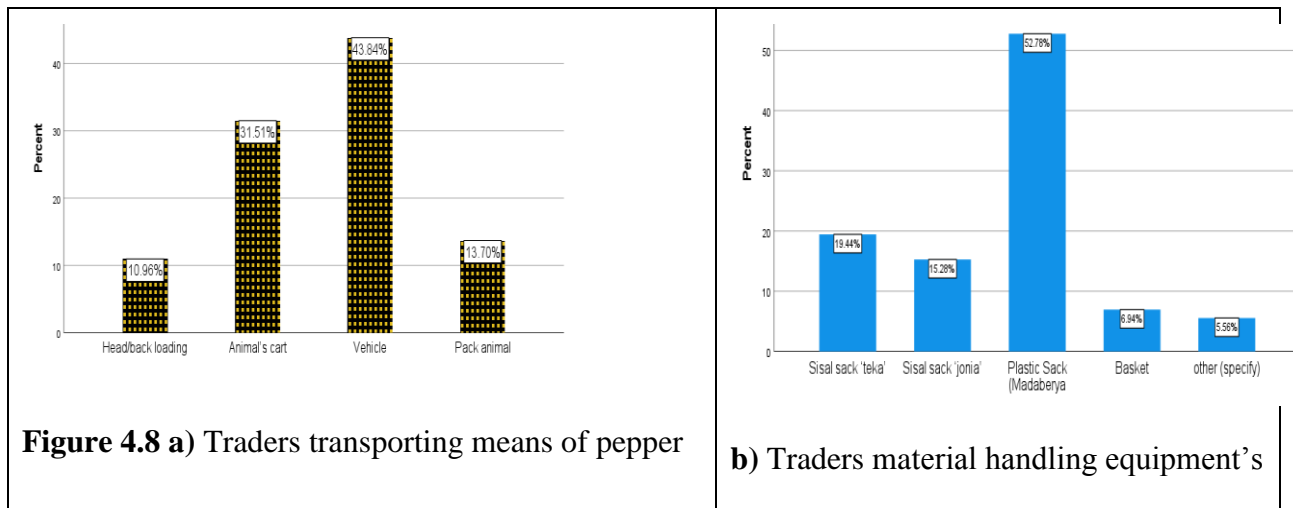


Figure 4.8 a) Traders transporting means of pepper

b) Traders material handling equipment's

B. Trader’s perception on storage

The majority of traders, 41.67% took pepper to storage aftermarket. When the pepper offered to the market did not sell at the desired price: 16.67% of traders took it to another nearby market, 27.78% will sell at a lower price.

Table 4.5 Pepper marketability and storage

Variables	Percent
Took to storage	41.67%
Took to another market	16.67%
Sell at lower price	27.78
Other	13.89%

From traders that were involved in the questionnaire, 75.81% claimed that they are not happy with the storage service available in Halaba Kulito town. Among them, 53.45% mentioned storage services available in Halaba towns are not a safe place, 18.97% responded price of storage to high, 17.24 % indicates storage place was far from the market, and other 10.34 % mentioned they don't know the location of storage place and other reasons.

The following bar chart shows the response of traders included in the questionnaire. They showed their idea about the change in quality and quantity of pepper after storage service in Halaba Kulito town

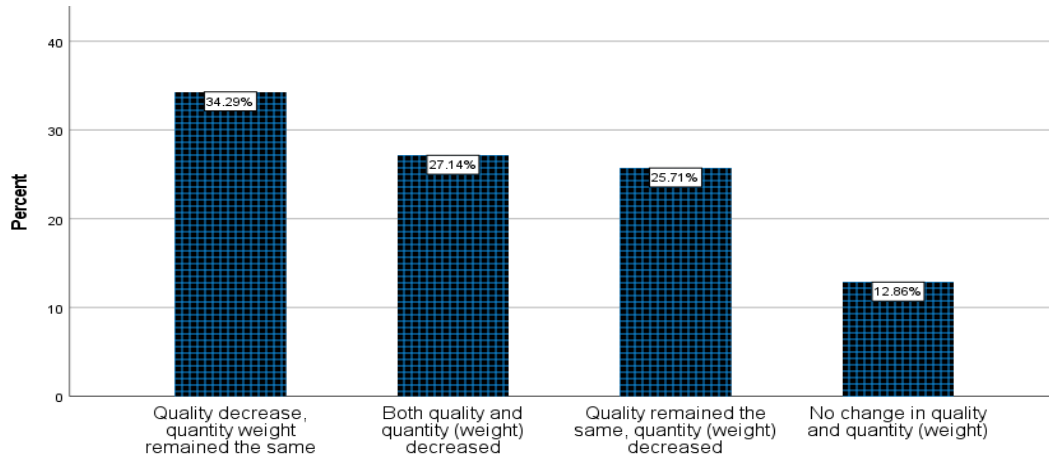


Figure 4.9: Change in pepper quality& quantity after storage

4.4 Semi structured interview with consumers

Consumers are the direct actors in the chain. They are the final stage actors or players in the red pepper supply chain. In the production to consumption system of red pepper, consumers purchase the products: from the producer, collector, retailers, or processors: for consumption. This means they are market actors who purchase either raw red pepper or processed red pepper for their consumption: directly from the producers: or they have many alternatives as they are the final destination of the products.

About three types of red pepper consumers were identified. They are households, restaurants, and institutions. Institutions are those that give services: higher educational institutions and hospitals are under this category.

Household-level consumers are employees and urban, rural dwellers: who purchase and consume red peppers. They purchase red pepper directly from producers, retailers, and wholesalers. Though, most of the consumers purchase from retailers. Farmers also make an important segment of the rural consumers: since they consume part of their produces. Institutions purchase the product from wholesalers: who have the capacity to supply regularly based on contractual agreements. Therefore, they have many options to purchase red pepper: they can buy from the harvesters, local collectors (broker), wholesalers, retailers, and processors.

Consumers of Halaba pepper are large in number. It requires more time and budget to address all consumers' perceptions. As there is time and budget constraint, randomly selected consumers' ideas on Halaba pepper are shown below. The quality issue was the first given complain about Halaba red pepper. According to consumers, they had difficulty in getting quality pepper. Usually in processed (milled) pepper mixing bad material is a habit of traders and Balitina shops for the sake of extra profit. This is very common in Addis Ababa and other Ethiopian cities. Also, it's difficult to get raw pure red pepper; if it's found very expensive.

Other issues raised about Halaba pepper were lack of direct supplier, scarcity of pepper, lack of information access about purchasing locations, price, and quality: are usual complains of Addis Ababa and other Ethiopian city consumers. Difficulty to find the right seller, bias by brokers, and cheating kilos (weight) during measuring was issues pointed by Halaba town consumers.

4.5 Observations

In this research an observation method was used to check reliability of data collected for analyzing existing logistics and supply chain practice of Halaba red pepper. So that case area market areas, storage places, transportation means, loading-unloading & packing trends and other key factors observed. The figure below shows some of observations In Halaba pepper logistics activities.



Figure 4.10 a) Pepper Filling Trend on Site b) Local Pepper Transportation Trend

4.6 Case study data analysis

A case study was used to collect data important for regression analysis, Pareto analysis, and optimization model development. In the case study, storage cost, transportation cost,

loading-unloading cost, and packing costs were recorded for 6 months. The data were analyzed as follows.

P1 stands for storage cost of local warehouse.

The warehouse was selected randomly from Halaba Kulito town. Its' storage cost per week, per 100 quintals: was recorded for 6 months. The selected warehouse was 20 square meters in area and has a height of 4 meters. Usually, storage takes place up to 3 meters to protect the pepper from overheating of the roof.

The volume of the warehouse was $0.2m \times 0.2m \times 3m = 1200$. Unit of packing was a plastic sack. And the standard volume dimension of 100kg plastic sack was length=1.2 meter width=1meter, height= 1.6meter. The volume of one quintal = 1.92 .So the total capacity of the warehouse was $1200 / 1.92 = 625$ quintal but considering the walkway: The average capacity is taken as 400 quintals.

Renting price of this warehouse were 12,000 Birr per month in Halaba Kulito. Initially, Storage costs were $12,000 \text{ Birr} / 400 \text{ quintal} = 30 \text{ birr}$ per month per quintal, which is 1birr per day for 1 quintal. In 6 months it increases from 1birr/quintal/day to 4 birr/quintal/day and the average cost was 2.375 birr/quintal/day. The recorded data of 6 months of storage per week of 100 quintals is shown below in Table as P1. P2 stands for transportation cost. Also, this is recorded for 6 months: from nearby pepper-producing wereda of Halaba, called Besheno to Kulito town. The distance of the carriage was 16km.it takes placed using a truck called lorry. Recorded data were transportation costs per 100 quintals of each week in one carriage.

P3 stands for loading unloading cost, here also 6 months unloading cost of 100 quintals using human labor were recorded and shown in the table

P4 stands for packing cost, and it is the sum of packing material and human labor cost for filling. At record 1, purchasing price of 100 kg packing material was 15 birr. And labor cost for filling 1 quintal was 10 birr. Therefore 100 quintal packing cost was $25 \times 100 = 2500$. The data through 6 months are shown in the table as P4. The 6-month price of pepper is also shown in the table. During record after 3 months, Pepper price increases a lot: due to corona virus epidemic

Table4.6: Six months recorded data of logistics activities cost and pepper price

Week	Storage cost in birr/week)/100qts	Transportation cost in birr/week)/100 qts	Loading unloading cost in birr/week) per100qts	Packaging cost in birr/week) per100qts	Weekly pepper Price in Birr/kg
1	700	1000	200	2500	50
2	700	1000	200	2500	60
3	700	1000	200	2500	50
4	875	1200	250	2500	70
5	875	1200	250	2500	70
6	875	1200	250	3000	60
7	1050	1200	300	3000	70
8	1050	1500	300	3000	80
9	1050	1500	300	3000	80
10	1050	1500	300	3000	90
11	1400	1500	350	3000	90
12	1400	2000	350	3300	90
13	1400	2000	350	3300	100
14	1575	2000	400	3500	100
15	1575	2500	400	3500	110
16	1750	2500	400	3600	110
17	1750	2500	450	3600	130
18	1925	3000	450	3700	130
19	1925	3000	500	3700	140
20	2100	3000	500	3700	150
21	2100	3500	550	3700	160
22	2450	3500	550	3800	170
23	2800	4000	600	3800	180
24	2800	4000	600	3800	200

4.7 Regression analysis

The need to use regression analysis is to show a statistical correlation between logistics activities cost with the price of pepper. Four key logistics activities costs obtained from the case study were computed with a price of pepper and the following result found

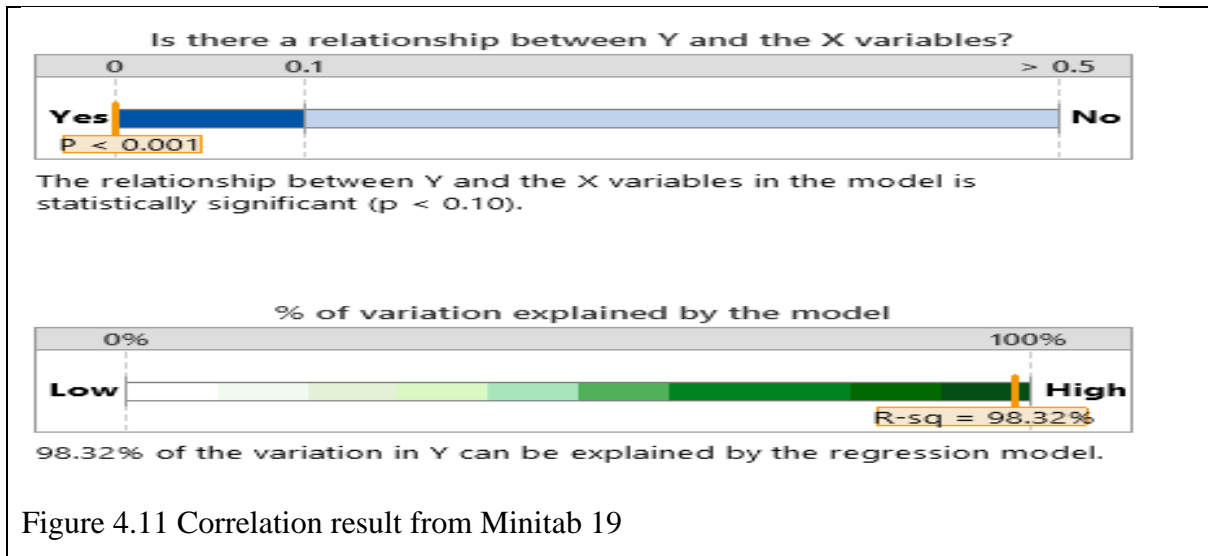


Figure 4.11 Correlation result from Minitab 19

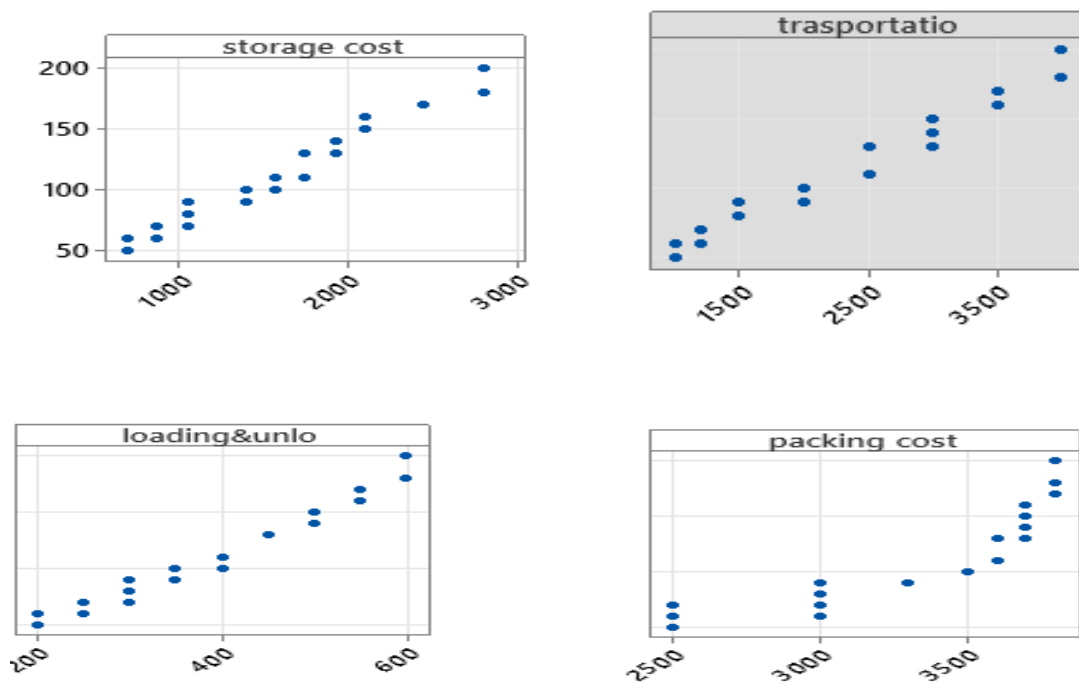


Figure 4.12 Graph of logistics activities relation with the price of pepper

The above 4 graph shows an exponential relationship: between costs of activities with the price of pepper. As they have a positive correlation, measures taken in minimizing logistics activities costs can also minimize the price of pepper.

Table 4.7: Pearson correlation result of logistics activities costs

	storage cost	Transportation cost	loading & unloading cost	packing cost
Transportation cost	0.982			
Loading & unloading cost	0.986	0.981		
packing cost	0.902	0.893	0.923	
price of pepper	0.983	0.983	0.985	0.873

4.8 Pareto analysis

Pareto analysis was used to identify the most contributing element of pepper logistics activity cost. It helps to focus improvement efforts on areas where the largest gain can be made.

The steps to construct Pareto chart using Microsoft Excel were, first raw data collected using case study. The data collected through case study were about logistics functions cost and price of pepper. Then the average cost of logistics function cost obtained. Later the percentage of each category and cumulative percentage computed. Finally through process in excel Pareto chart found.

Based on computation using Pareto analysis; packing and transportation cost becomes the most contributing element to pepper logistics activity cost. This research gives priority to transportation cost minimization, solution methods than packing. This decision is made considering complexity. Compared with packing, transportation modeling is very complex and requires more effort to gain solutions. Therefore, the researcher gives priority to transportation modeling. And the work in packing opened for future work.

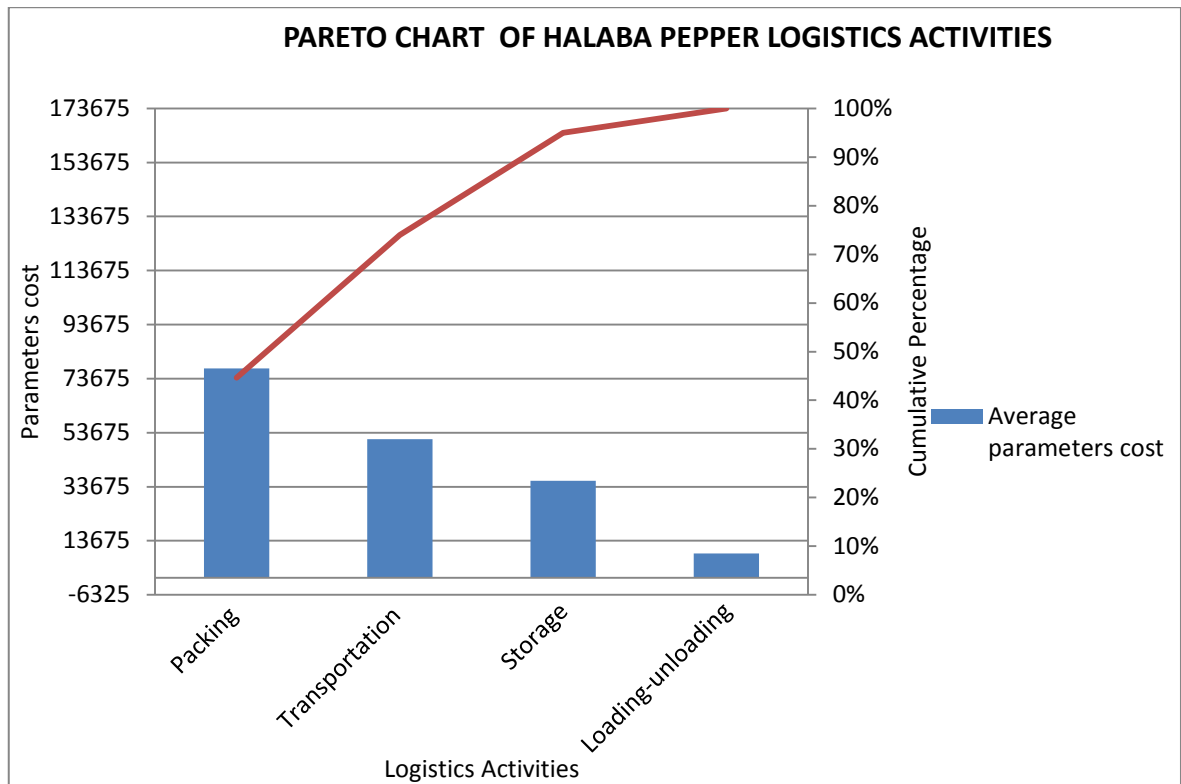


Figure 4.13: Pareto Chart of Halaba Pepper Logistics Activities

4.9 Transportation modeling

This Transportation modeling considers several origins and destinations with the goal to optimize a solution at minimal cost by minimizing transport costs. As it is a deterministic model, the values of parameters and constraints are certainly determined. For this research, to optimize Halaba red pepper transportation problem linear programming mathematical model is used.

4.9.1 Shortest path

The need to determine the shortest path is to minimize the travel distance between Halaba markets and the central market of the country Addis Ababa. Minimizing travel distance means minimizing transportation cost which indirectly means minimizing supply chain cost. Therefore the shortest route result obtained from this analysis will be used in the transportation model formulation.

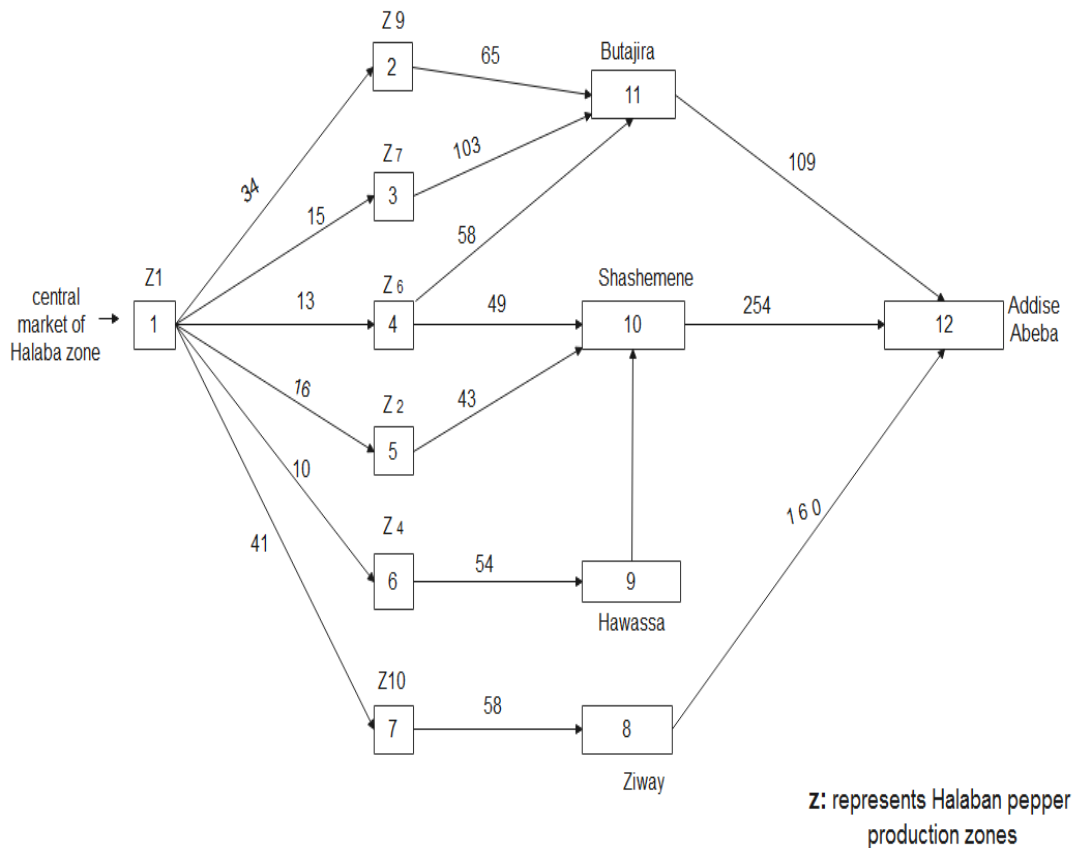


Figure 4.14 Shortest route diagram

The above shortest route model is to determine the shortest distance between central market of Halaba zone(Z1) and Addis Ababa which is the central market of the country . Therefore In the above shortest route model nodes represented by number. Nodes represented by 1-7 are Halaba zone production districts. The districts have road infrastructure for transportation and supplies specific amount of pepper. Node10 (Butajira) and node 11(Shashemene) are the two existing different transportation route to Addis Ababa from Halaba. Node 8(Hawassa) and node 9 (Ziway) are considered in this shortest route model because they are new emerging road transportation routes under construction. They are constructed by Ethiopian Road Authority.

The shortest route analysed using excel QM software and shown below in the following tables.

Table 4.8: Shortest route analyses using QM software

Branch Name	Start Node	End Node	Distance
Branch 1	1	2	34
Branch 2	1	3	15
Branch 3	1	4	13
Branch 4	1	5	16
Branch 5	1	6	10
Branch 6	1	7	41
Branch 7	2	11	65
Branch 8	3	11	103
Branch 9	4	11	58
Branch 10	4	10	49
Branch 11	5	10	43
Branch 12	6	9	54
Branch 13	9	10	23
Branch 14	7	8	58
Branch 15	11	12	109
Branch 16	10	12	254
Branch 17	8	12	160

The analysis using Excel Qm indicates Road transportation route 1-4-11-12 as the shortest road transportation distance between central market of Halaba Kulito and Addis Ababa

Table 4.9 Shortest route result obtained from QM software

Branches	Start Node	End Node	Distance (km)	Cumulative Distance
Branch 3	1	4	13	13
Branch 9	4	11	58	71
Branch 15	11	12	109	180

The result shows Route 1-4-11-12 can minimize transportation distance to Addis Ababa from Halaba kulito. The obtained shortest route can minimize transportation cost that happen due to transportation distance.

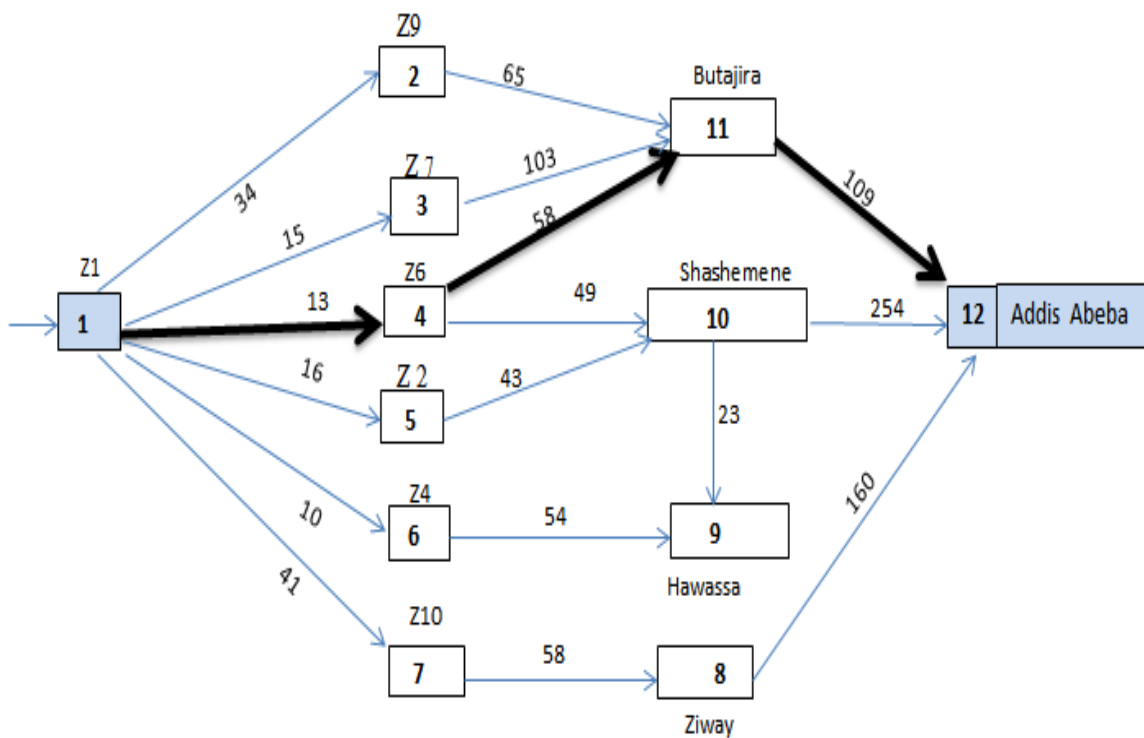


Figure 4.15 Shortest route to Addise Ababa city from Halaba kulito town

A. Comparison of routes of Addis Ababa

In the actual Halaba pepper supply trend, red pepper supplied to Addis Ababa and other potential markets of the country from Kulito town. The existing pepper transportation trend to Addis Ababa takes places through two routes.

The first pepper transporting route is from Kulito town (z1) through Shashemene, which is route 1-4-10-12 in the figure 4.15. It covers 306 kilo meters. The second existing route to Addis Ababa is route 1-2-11-12 in the Figure 4.15. This is transportation from Kulito town to Addis Ababa through Butajira town. It has a total distance of 208 kilo meters. Compared to existing Shashemene route, this route saves 98 kilo meters. It means 32% of total distance through the Shashemene route.

Figure 4.15, shows route 2-11-12, as the shortest route to Addis Ababa. But the existing pepper supply to Addis Ababa starts from kulito town (Z1).comparing route 2-1-12 with existing pepper supply route to Addis Ababa. Route 2-1-12 is the least in distance.

Table below shows a comparison of distance between the existing routes of pepper supply to Addis Ababa with proposed shortest route (2-1-12) of pepper supply to destination market Addis Ababa.

Table 4.10: Comparison of routes of Pepper supply to Addis Ababa

Route name	Route number in shortest route diagram	Distance	Saved distance compared to route through Shashemene		Saved distance compared to route through Butajira	
			In kilo meters	In percentiles	In kilo meters	In percentiles
New shortest route	2-11-12.	174km	132km	43.14%	34km	16.4%
Existing route through Shashemene	1-4-10-12	316km	-	-	-	-
Existing route through Shashemene	1-2-11-12	208km	-	-	-	-

B. Comparison of supply routes of Hawassa

The existing route of pepper supply from Halaba kulito to Hawassa is through Shashemene and it is route 1-4-10-9 in the shortest route diagram (Figure 4.15). The table below shows a comparison of the saved distance between the existing route and new route obtained from shortest route analysis: to destination market Hawassa: for supplying red pepper from Halaba zone.

Table 4.11: Shortest route result obtained from QM software

Route	Distance	Saved distance compared to old route in km	Saved distance compared to old route in percent
6-9	54km	31km	57.4%
1-6-9	64km	21km	24.7%
5-10-9	66km	19km	22.35%
4-10-9	72km	13km	15.29%

All mentioned routes in the table can save distance compared to the existing supply route of pepper to Hawassa. But Route 6-9 in the figure 4.15 is the route that takes the least distance for pepper transportation to Hawassa. The new route 6-9 is through Ropi town and has got new road under construction by Ethiopian roads authority.

Therefore this route is recommended route for red pepper transportation to Hawassa.

4.9.2 Linear programming model for transportation

This Transportation modeling is done based on 2019/2020 supply and demand Report. Supplied quantity of pepper per year from each production zone is shown below in table

Transportation model assumptions

- The Establishment of a distribution center in 10 production zones of Halaba is assumed.
- Supply is considered from proposed distribution center.
- Each distribution center gets its supply from a nearby production district: that encompasses peasant administration.

For clarity, Z1 which means distribution center 1 gets its supply from nearby production district D1&D4. Therefore, the supply amount which used in the LP model is calculated as follows.

$$Z_1 = D_1 + (D_4/2), Z_2 = D_2 + (D_3/2) + D_9, Z_3 = D_5/2, Z_4 = D_4/2, Z_5 = D_5/2, Z_6 = D_3/2, Z_7 = D_8 + D_{11}, Z_8 = D_7, Z_9 = D_6, Z_{10} = D_{10}$$

‘D’ represents the maximum supply of pepper in 2019/20 from the Halaba zone Production district. Where ‘Z’ represents the maximum supply capacity of the proposed distribution center: and shown in the table below.

Table 4.12: Supply capacity of pepper from each production zone

Production zone (Z)	Maximum supply Quantity
Z1	27848
Z2	53886
Z3	7890
Z4	8400
Z5	7890
Z6	8765
Z7	35200
Z8	11735
Z9	22394
Z10	16546

Cost of transportation per quintal, to four destination markets, from each production zone: obtained depending on the shortest distance. The cost of transporting one quintal of pepper from each production zone to the destination market differs according to the distance and type of road.

Table 4.13: Transportation cost per quintal to destination markets from production zones

Production Zone (Z)	Destination market			
	Cost of carriage (birr/quintal, km)			
	A.A (A)	Hawassa (B)	Welayita Sodo(C)	Hossana (D)
Z1	54	19	22	15
Z2	89	20	26	20
Z3	59	24	17	19
Z4	99	16	25	18
Z5	57	22	24	12
Z6	50	22	26	19
Z7	64	26	26	19
Z8	45	21	44	37
Z9	52	30	34	25
Z10	65	27	36	27

- Transportation cost (carriage /quintal *birr) = (transportation distance to destination market from production zone(Z))*(carriage cost /quintal *km)
- Carriage cost /quintal *km= 0.30 birr/quintal*km

The following table shows the average demand for pepper from the potential market. It's found by calculation based on weekly sales record of pepper for 5 years. The data was found from the Halaba zone trade and industry office. Some approximation had taken.

Table 4.14: Pepper demand of 4 potential areas of the country in 2019/20

Market	Estimated demand in the year
A.A	100,000
Hawassa	30,000
Hossana	25,000
Welayita	25,000

The work below is to found, how many quintals of pepper to transport from the production zone to destination market: to minimize the total cost of transportation.

The general formulation of a transportation problem is

$$\text{Min } \sum_{i=1}^{i=m} \sum_{j=1}^{j=n} c_{ij} x_{ij}$$

$$\text{Subject to } \sum_{j=1}^{j=n} x_{ij} \leq s_i \quad (i=1, 2, 3, m) \quad \text{supply constraint}$$

$$\sum_{i=1}^{i=m} x_{ij} \geq d_j \quad (j=1, 2, \dots, n) \quad \text{demand constraint}$$

$$x_{ij} \geq 0$$

$$\text{Minimize } Z=54X_{1A}+19X_{1B}+22X_{1C}+15X_{1D}+89X_{2A}+20X_{2B}+26X_{2C}+20X_{2D}+59X_{3A}+24X_{3B}+17X_{3C}+19X_{3D}+99X_{4A}+16X_{4B}+25X_{4C}+18X_{4D}+57X_{5A}+22X_{5B}+24X_{5C}+12X_{5D}+50X_{6A}+22X_{6B}+26X_{6C}+19X_{6D}+64X_{7A}+26X_{7B}+26X_{7C}+19X_{7D}+45X_{8A}+21X_{8B}+44X_{8C}+37X_{8D}+52X_{9A}+30X_{9B}+34X_{9C}+25X_{9D}+ 65X_{10A}+27X_{10B}+36X_{10C}+27X_{10D}.$$

The objective function reflects the total transportation cost of quintals transported for one route

Supply constraint

$$X_{1A}+ X_{1B}+ X_{1C}+ X_{1D} \leq 27,848$$

$$X_{2A}+ X_{2B}+ X_{2C}+ X_{2D} \leq 53,886$$

$$X_{3A}+X_{3B}+X_{3C}+X_{3D} \leq 7890$$

$$X_{4A}+ X_{4B}+ X_{4C}+ X_{4D} \leq 8400$$

$$X_{5A} + X_{5B} + X_{5C} + X_{5D} \leq 7890$$

$$X_{6A} + X_{6B} + X_{6C} + X_{6D} \leq 8765$$

$$X_{7A} + X_{7B} + X_{7C} + X_{7D} \leq 35,200$$

$$X_{8A} + X_{8B} + X_{8C} + X_{8D} \leq 11735$$

$$X_{9A} + X_{9B} + X_{9C} + X_{9D} \leq 22394$$

$$X_{10A} + X_{10B} + X_{10C} + X_{10D} \leq 16,546$$

Demand constraint

$$X_{1A} + X_{2A} + X_{3A} + X_{4A} + X_{5A} + X_{6A} + X_{7A} + X_{8A} + X_{9A} + X_{10A} \geq 100,000$$

$$X_{1B} + X_{2B} + X_{3B} + X_{4B} + X_{5B} + X_{6B} + X_{7B} + X_{8B} + X_{9B} + X_{10B} \geq 30,000$$

$$X_{1C} + X_{2C} + X_{3C} + X_{4C} + X_{5C} + X_{6C} + X_{7C} + X_{8C} + X_{9C} + X_{10C} \geq 25,000$$

$$X_{1D} + X_{2D} + X_{3D} + X_{4D} + X_{5D} + X_{6D} + X_{7D} + X_{8D} + X_{9D} + X_{10D} \geq 25,000$$

In this model the decision variable x_{ij} represents the number of quintal of pepper transported from each supply zone

Table 4.15: Solution from QM software

Costs	A.A	Hawassa	Welayita Sodo	Hossana
Z 1	54	19	22	15
Z 2	89	20	26	20
Z 3	59	24	17	19
Z 4	99	16	25	18
Z 5	57	22	24	12
Z 6	50	22	26	19
Z 7	64	26	26	19
Z 8	45	21	44	37
Z 9	52	30	34	25
Z 10	65	27	36	27
Demand	100000	30000	25000	25000

The result in the following table shows in order to minimize the transportation cost of carriage to Addis Ababa: supply from production zone 1 is optimal. For Hawassa demand supply from production zone 2 &4 in shown quantity is suggested. For Welayita demand supply from production zone, 2&3 in given quantity is optimal. For Hossana supply from production zone 2, 5 & 7 recommended. In doing so the total transportation of carriage becomes 7,083,445 Birr

Table 4.16 Optimality output of QM software

Shipments	Addis Ababa	Hawassa	Welayita Sodo	Hossana	Row Total
Z 1	27848	0	0	0	27848
Z 2	0	21600	17110	11168	49878
Z 3	0	0	7890	0	7890
Z 4	0	8400	0	0	8400
Z 5	0	0	0	7890	7890
Z 6	8765	0	0	0	8765
Z 7	29258	0	0	5942	35200
Z 8	11735	0	0	0	11735
Z 9	22394	0	0	0	22394
Z 10	0	0	0	0	0
Column Total	100000	30000	25000	25000	180000 \180000
Total Cost	7,083,445				

4.10 Model verification

In the previous Halaban pepper supply channel, every produced pepper in production zones were collected to the central market, and then distribution to the country through regional wholesalers. In the old trend, there was mainly two transportation cost. The first one, from production zones to the central market of the Halaba zone: and from the central market of the Halaba zone to potential markets of the country.

Taking average transportation cost: from production zones to the central market of Halaba zone 10 birr. Multiplying by average supplied quantity to 4 potential markets of Ethiopia in the year 2019\20: which is 180,000 quintal. Transportation cost from the production zone to the central market of Halaba becomes

$$=10\text{birr/quintal} * 180,000 \text{ quintal}$$

$$=1,800,000 \text{ birr}$$

The second transportation cost is from the central market of Halaba to the 4 potential markets of the country. It is a multiple of, summation of, supplied quantity in the year 2019/20, to every 4 potential markets of the country: and its transportation cost per quintal.

$$\sum (\text{supplied quantity in quintal}) * (\text{transportationcost per quintal})$$

$$= (100,000 \text{ q} * 54 \text{ birr/q}) + (30,000\text{q} * 19\text{birr/q}) + (25,000\text{q} * 22\text{birr/q}) + (25000\text{q} * 15\text{birr/q})$$

$$=6,895,000 \text{ birr}$$

Total transportation to 4 potential markets of the country, in the old supply of pepper, in the year 2019/20 becomes

$$=1,800,000 \text{ birr} + 6,895,000 \text{ birr}$$

$$= 8,695,000\text{birr.}$$

Comparing this value, with transportation cost of newly developed LP model:

$$8,695,000 \text{ birr} - 7,083,445\text{birr}$$

$$=1,611,555\text{birr}$$

New LP model saves such money from transportation cost. This implies

Newly proposed distribution center can minimize transportation cost of pepper in 18.5343 %. This implies the new built model is valid.

4.11 Proposed distribution centers

This research work proposes establishment of ten distribution centers, in 10 productions zone of Halaba region. The proposal is based on analysis of production capacity, availability of transportation route and proximity to potential market of the country including terminal market Addis Ababa.

The proposed distribution centers are shown below in the map of Halaba zone.

Supplying production zone for proposed distribution centers are shown in the table below.

Table 4.17: Distribution centers and proximity potential markets

Proposed Distribution Center (D.C)	Location number in Atlas map	Supplier Production zone (z)	Proximate to potential market
D.C 1	51(kulito)	Z1, Z4	Central market (kulito)
D.C 2	19	Z2, Z3&Z9	Hawassa through Shashemene
D.C 3	7	Z5	Welayita Sodo
D.C 4	44	Z4	Hawassa through Ropi
D.C 5	11	Z5	Hossana
D.C 6	47	Z3	Addis Ababa through Butajira
D.C 7	35	Z8&Z11	Addis Ababa through Werabe- Butajira
D.C 8	43	Z7	Addis Ababa through Ziway
D.C 9	36	Z6	Addis Ababa through A/gebeya- Butajira
D.C 10	66	Z10	Collecting ware house

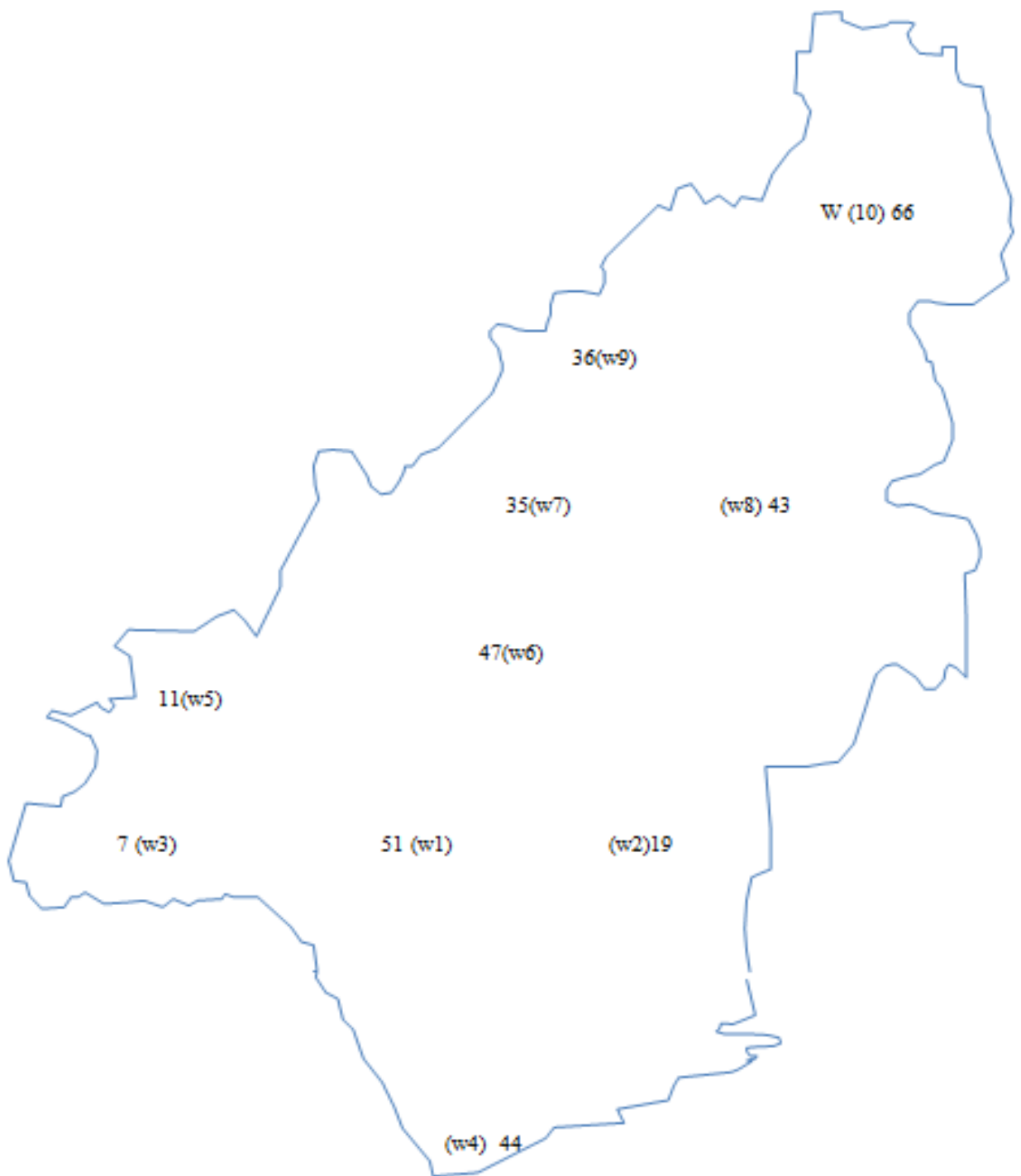


Fig 4.16: proposed distribution centers shown in Halaban map

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1: CONCLUSION

In this paper the researcher identified the problems related with supply chain network and reviewed different literatures, scenarios and methods to solve the problems. The problem was modeled and solved as a linear programming. Excel QM software was used in solving proposed optimization model of transportation. The research can play a significance role in minimizing supply chain cost. Optimization on post-harvest logistics operation mainly in transportation can create a significant difference in price of red pepper. In the built transportation optimization model using LP: taking a supply chain route to four Ethiopian potential markets. Transportation cost minimized in 18.5% Minimizing transportation cost means minimizing price of pepper. As transportation is among function of logistics and logistics is among the function of supply chain management. In this relationship minimizing transportation cost means minimizing supply chain cost.

In other way minimizing loss of pepper through improving poor practices during logistics activities increases supply of pepper. As pepper is one of food inputs, through Increasing pepper supply: this thesis work can play a significance role in minimizing food shortage.

Therefore application of this model in different scenarios, by different Parameters, constraint, and decision variables: can give positive result in minimizing inflation of price of product and mitigates food shortage.

5.2 RECOMMENDATION

The researcher has made some recommendations based on the study that has been conducted. First of all, the researcher would like to recommend establishment of distribution centers in the production zone. The establishment of DC plays critical role in consumer demand satisfaction in fair price. Also it can contribute to producers' profitability.

Proposed transportation model has positive result in minimizing transportation cost. So that, the researcher recommends, implementation of proposed model. Implementing the model benefits the producers and stake holders of the supply chain as well as consumers. Route 1-2-11- 12 recommended for carriage to Addis Ababa from Kulito town through Butajira city. The route can minimize transportation distance, time& cost. In advance it's possible to minimize transportation distance to Addis Ababa by establishing distribution center in Z9 (production zone 9). Route 1-6-9 in the shortest route diagram is recommended: for red pepper supply transportation of Hawassa. Because it is more effective route compared to the old route.

The other recommendation is on packing: the researcher recommends plastic sack rather than other traditional means of packing. For filling the sacks it's good &more efficient to use machines than human labour.

For loading unloading it's more efficient using forklift rather than human labour. So the researcher recommends forklift especially during loading unloading in kulito town storage places.

5.3 FUTURE WORK

As the author proposed, establishment of distribution centers in production zone.

Designing ware house and inventory management model is required to be conducted in the future research work.

In advance to minimize loss of pepper: it's also required to do further research work on packing and loading unloading.

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APPENDIX 1

QUESTIONNAIRES

I, QUESTIONNAIRE FOR FARMERS

HAWASSA UNIVERSITY

INSTITUTE OF TECHNOLOGY

FACULTY OF MANUFACTURING

DEPARTMENT OF INDUSTRIAL ENGINEERING

Master's Program in Industrial Engineering and Logistics Management

Modeling Post-Harvest Logistics Operation of Pepper: A Case of Halaba Zone

I. Dear Respondent,

Hawassa university master's thesis entitled "modeling post-harvest logistics operation of pepper: a case of halaba zone" with the objective to carry out an in-depth supply chain analysis to generate sufficient information on the main opportunities and bottlenecks for Halaba pepper distribution. This study is likely to contribute significantly to distribution of Halaba pepper. Put (X) to each answer where you feel appropriate. Your response will only be used for survey purposes and never be shared. In case you have any questions regarding the survey, please call Bereket Tadiwos 0910672490 Thank you very much for your time and suggestions.

Questionnaire number: _____

Name of enumerator: _____

Date: ____/____/____

Q1. What was common problem you face during pepper transportation from farm to store as well to market?

1. Lack of material handling equipment
2. Lack of proper transportation means

Q2. What was your commonly used material handling equipment?

- 1 Sisal sack 'teka' 2 Plastic Sack (Madaberya)

3 Baskets 4 other traditional means) -----

Q3. How did you transport pepper from farm to home as well to market?

1. Head/back loading 2. Animal's cart 3 Pack animal 4. Cars

Q4.do you encounter loss of pepper during transportation

1. Yes 2. No

Q5. If yes what are the common cause of loss of pepper?

1. Material handling defect

2. Loss due to transporting material problems

3. Infrastructure problems

4. Weather condition

Q6. Did you store pepper after production in 2019/20?

1=Yes 2 =No

Q7. If yes: how long did you store, in months?

1. Below 1 month 2.1-3 months 3. 3-6 months 4 .Above 6 months

Q8. How did you store the pepper? »

1. Placing in 'kot' 2.Placing in store/'gotera' 3.Placing in living home

Q9. What were common problem you encounter during storage?

1. Vulnerability to moisture (rain fall),

2. Vulnerability to heat

3 Vulnerability to insects

Q10. Was there any change in the quantity (weight) and quality of the stored pepper?

1 Quality decrease, quantity weight remained the same

2 Both quality and quantity (weight) decreased

3 Quality remained the same, quantity (weight) decreased

4 No change in quality and quantity (weight)

Q11. What were common problems you faced during pepper marketing?

1. Lack of nearby market
2. Lack of Demand
3. Lack of Information on price of pepper
4. Fraud and theft by brokers and merchants

II, QUESTIONNAIRE FOR TRADERS

HAWASSA UNIVERSITY

INSTITUTE OF TECHNOLOGY

FACULTY OF MANUFACTURING

DEPARTMENT OF INDUSTRIAL ENGINEERING

Master's Program in Industrial Engineering and Logistics Management

Modeling Post-Harvest Logistics Operation of Pepper: A Case of Halaba Zone

I. Dear Respondent,

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Questionnaire number: _____

Name of enumerator: _____

Date: ____/____/____

Q1. How did you transport pepper from home (warehouse) to market? »

- 1 Head/back loading 2 Animal's cart

3 Car 4 Pack animal

Q2. What did you do, when the pepper you offered to the market was not sold? »

- 1 Took to storage 3. Sell at lower price
2 Took to another market 4. other

Q3. What was your packaging material when you sold? »

- 1 Sisal sack 'teka' 3 Plastic Sack (Madaberya) 5 other (specify) -----
2 Sisal sack 'jonia' 4 Basket

Q4. Do you insert water in time of packing? 1. Yes 2. no

Q5. If yes what were your motive?

1. To gain more weight at the time of sale and in turn to gain more price
2. Other reason

Q6. Are you satisfied in warehouse service?

1. Yes 2. No

Q7. If no what were your reason?

1. Storage places are not safe and they result loss.
2. Price of storage too high
3. Too far from market
4. Other reason

Q8. Was there any change in the quantity (weight) and quality of the stored pepper?

1. Quality decrease, quantity weight remained the same
2. Both quality and quantity (weight) decreased
3. Quality remained the same, quantity (weight) decreased
4. No change in quality and quantity (weight)

Q9. When quantity loss of pepper usually happens: during supply chain of pepper?

1. during storage 3. during packing

- 2. During transportation
- 4. during loading & unloading

መጠይቅ 1 ለገበሬዎች (አምራቾች)

የገበሬዎች መጠይቅ

ውድ መልስ ሰጪዎች ይህ መጠይቅ የተዘጋጀው ለሁለተኛ ዲግሪ መመሪያ ፅሁፍ መረጃ ለመሰብሰብ የሚያግዝ ሲሆን ሌላ ምንም ዓይነት አላማ እንደሌለው አረጋግጣለሁ። ለሚስጡኝ መረጃ ከልብ እያመሰገንኩ በጥያቄዎቹ ላይ ግልፅ ያልሆኑ ነገሮች ካሉ በረከት ታዲያስ 09 10 67 2490 መደወል ይችላሉ

1. በ2011/2012 በርበሬ መጋዘን አስቀምጠው ያውቃሉ? 1= አዎ 2=አይ

2. መልስዎ አዎ ከሆነ ለምን ያክል ወር? -----

3. በርበሬውን እንዴት ነው ሚያስቀምጡት?

1 በማዳበርያ በማድረግ ቆጥ ላይ ሰቅለዋለሁ 2 ኅተራ ዐጠራቅመዋለሁ 3 በሌላ መንገድ ነው ማጠራቅመው

4. ሚያጠራቅሙ ከሆነ ምክንያቱ ምንድነው?

1 ከፍ ያለ ሽያጭ በመጠበቅ 3 ለቁጠባ

2 ገዥ በማጣት 4 ሌላ ምክንያት

5. በምያጠራቅሙበት ጊዜ የጥራትና የብዛት ልዩነት አለን?

1 ጥራቱ ይቀንሳል ብዛት ግን ተመሳሳይ ነው?

2 ብዛቱም ጥራቱም ይቀንሳል

3 ጥራቱ ተመሳሳይ ነው፤ ብዛቱ ግን ይቀንሳል

4 ብዛቱም ጥራቱም ተመሳሳይ ነው

6. በርበሬውን ሲሸጡ ማሸግያው ምንድነው?

1 ቴካ 2 ጅንያ 3 ማዳበርያ 4 ቅርጫት 5 ሌላ

7. ለመሸጥ በሚፈልጉበት ጊዜ ይስተጋጎላሉ? 1አዎ 2አይ

8. መልስዎ አዎ ከሆነ ምክንያቱ ምንድነው ብለው ያስባሉ?

1 የማጋጋዥ መንገድ ማጣት 3 የመረጃ ማጣት

2 ዝቅተኛ ሂሳብ መስጠት 4 ሌላ ምክንያት

9. ለገበያ ያቀረቡት በርበሬ በማይሸጥበት ጊዜ ምንድነው ሚያደርጉት?

- 1, መጋዘን አስቀምጠዋለሁ 3 በቅናሽ ሂሳብ ሸጠዋለሁ
- 2 ወደ ሌላ ገበያ ወስደዋለሁ 4 ሌላ ሚያደርጉት ነገር ካለ

ሀሳብን ስላካፈሉን ክልብ አመሰግናለሁ።

መጠይቅ 2 ለነጋዴዎች

ውድ መልስ ሰጪዎች ይህ መጠይቅ የተዘጋጀው ለሁለተኛ ዲግሪ መመሪያ ፅሁፍ መረጃ ለመሰብሰብ የሚያግዝ ሲሆን ሌላ ምንም ዓይነት አላማ እንደሌለው አረጋግጣለሁ። ለሚሰጡኝ መረጃ ክልብ እያመሰገንኩ በጥያቄዎቼ ላይ ግልፅ ያልሆኑ ነገሮች ካሉ በረከት ታዲያስ 09 10 67 2490 መደወል ይችላሉ

1 በርበሬ ከማን ነው ሚገዙት

- 1 ከአምራች ገበሬ 2 ከነጋዴ ገበሬዎች

- 3 ከክልል አቀፍ ጅልማ ሻጮች 4 ከከተማ አቀፍ ጅልማ ሻጮች

2. በርበሬን ከቤት ወደ ገበያ የሚያጋጉዙት እንዴት ነው?

- 1 በሰው ትኩረት በመሸከም 2፣በጋሪ
- 3 በመኪና 4 በጭነት እንስሳት 5 በሌላ መንገድ

3. ለገበያ ያቀረቡት በርበሬ በማይሸጥበት ጊዜ ምንድነው ሚያደርጉት?

- 1, መጋዘን አስቀምጠዋለሁ 3 በቅናሽ ሂሳብ ሸጠዋለሁ
- 2 ወደ ሌላ ገበያ ወስደዋለሁ 4 ሌላ ሚያደርጉት ነገር ካለ

4. በርበሬውን ሲሸጡ ማሻግያው ምንድነው?

- 1 ቱካ 2 ጆንያ 3 ማዳበርያ 4 ቅርጫት 5 ሌላ

5. በርበሬን ለመሸጥ በመዳበርያ በሚጨምሩበት ጊዜ ውሃ ይጨምሩበታል?

- 1 አዎ 2 አይ

6. ሚጨምሩ ከሆነ ምክንያቱ ምንድነው

- 1. ኪሎ እንድጨምርልኝና ተጨማሪ ክፍያ ለማግኘት
- 2. ሌላ ምክንያት

7. በርበሬን በኪራይ መጋዘኖች በሚያጠራቅሙበት ጊዜ በሚያገኙት አገልግሎት ደስተኛ ናትን

1 አዎ ነኝ 2 አይደለሁም

8. ደስተኛ ካልሆኑ ምክንያቶች ምንድነው

1 መጋዘኖቹ ብክነት ያስከትላሉ 2 የመጋዘን ኪራይ ሂሳብ ውድ ነው

3 ከገበያ ይርቃሉ 4 ሌላ ምክንያት

9. በምያጠራቅሙበት ጊዜ የጥራትና የብዛት ልዩነት አለን?

1. ጥራቱ ይቀንሳል ብዛት ግን ተመሳሳይ ነው?

2 ብዛቱም ጥራቱም ይቀንሳል

3 ጥራቱ ተመሳሳይ ነው፤ ብዛቱ ግን ይቀንሳል

4 ብዛቱም ጥራቱም ተመሳሳይ ነው

10. በእርሶ እይታ በርበሬ የሽያጭ ሰንሰለት ውስጥ በአብዛኛው ብክነት የሚታየው መች ነው

1. መጋዘን በሚቀመጥበት ጊዜ 2 በማዳበርያ በሚጨመርበት ጊዜ

3. በሚጋጋዝበት ወቅት 3. በሚጫንበትና በሚወርድበት ወቅት

ሀሳብን ስላካፈሉን ከልብ አመሰግናለሁ።

INTERVIEW QUESTIONS FOR HALABA PEPPER CONSUMERS

1. Are you consumer of Halaba pepper?

2. If you are consumer of Halaba pepper from where you purchase pepper?

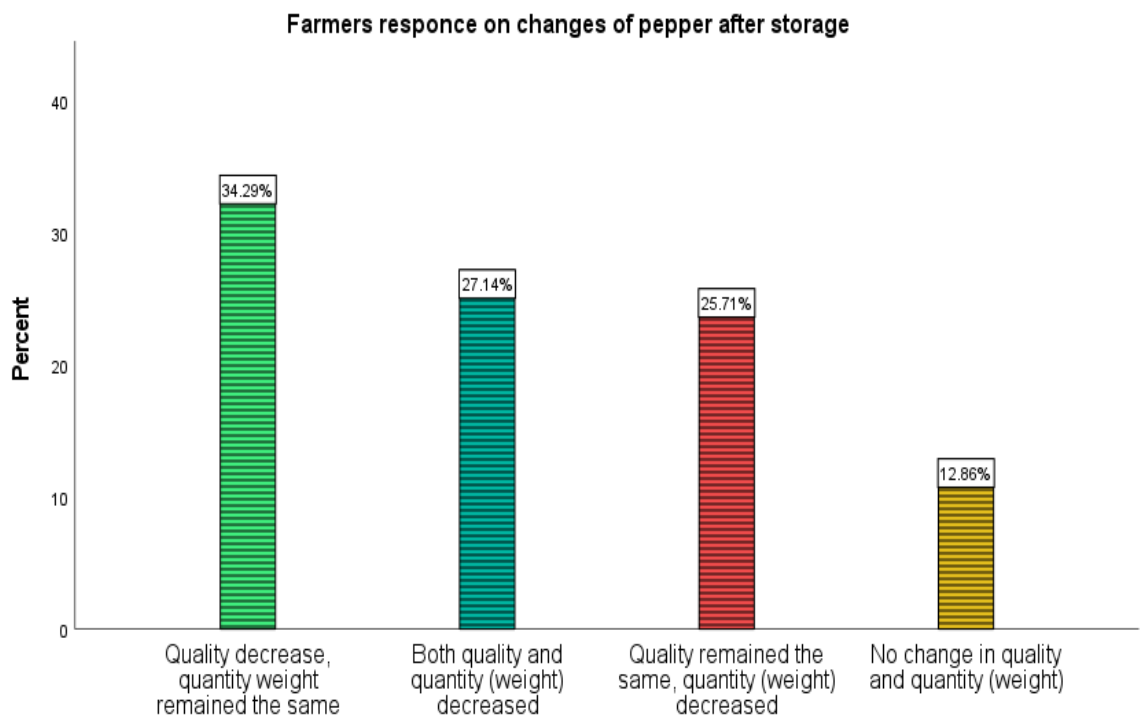
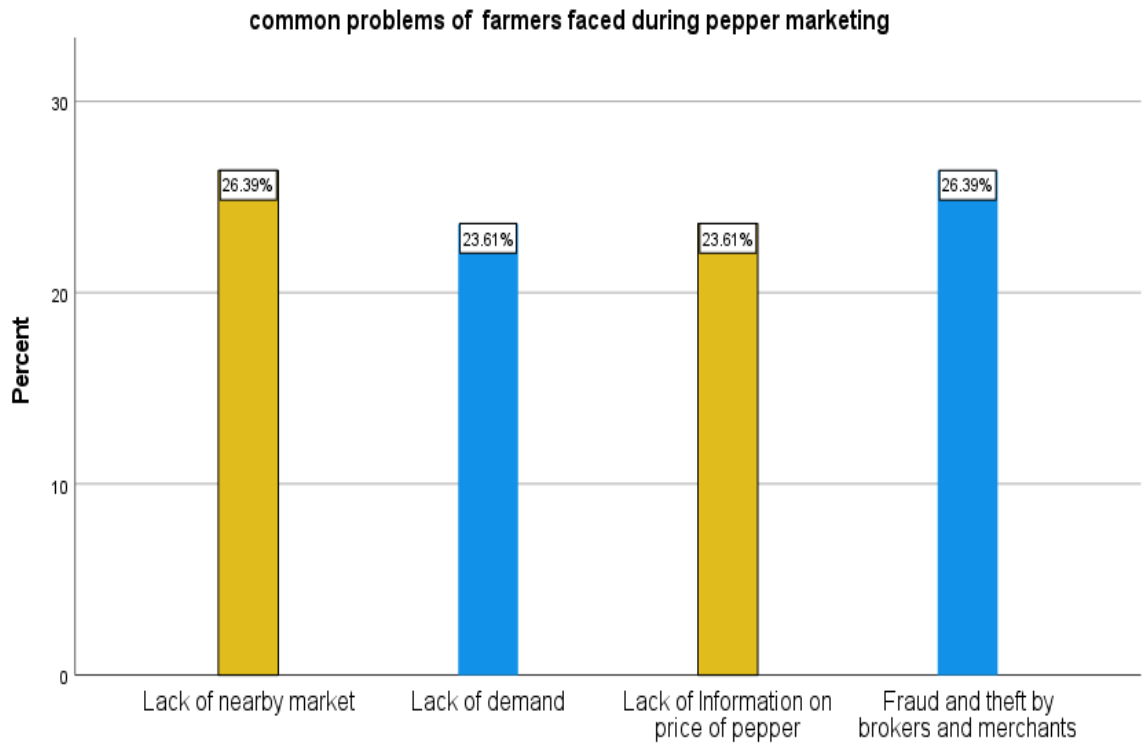
3. Do you get enough supply?

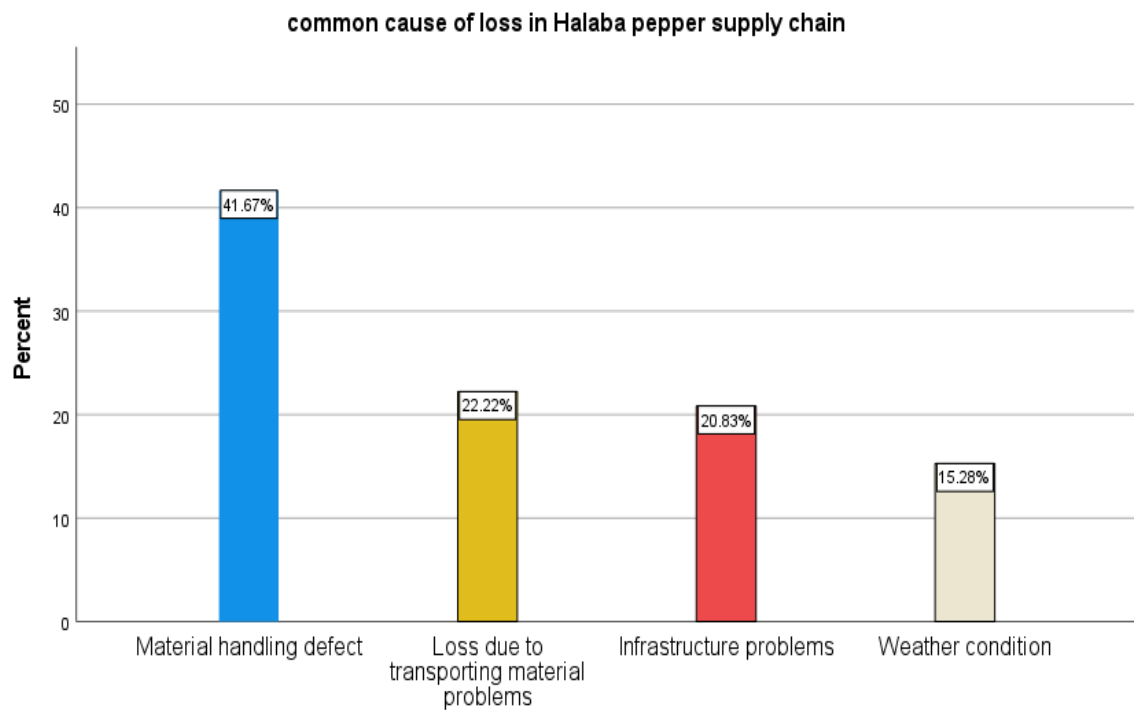
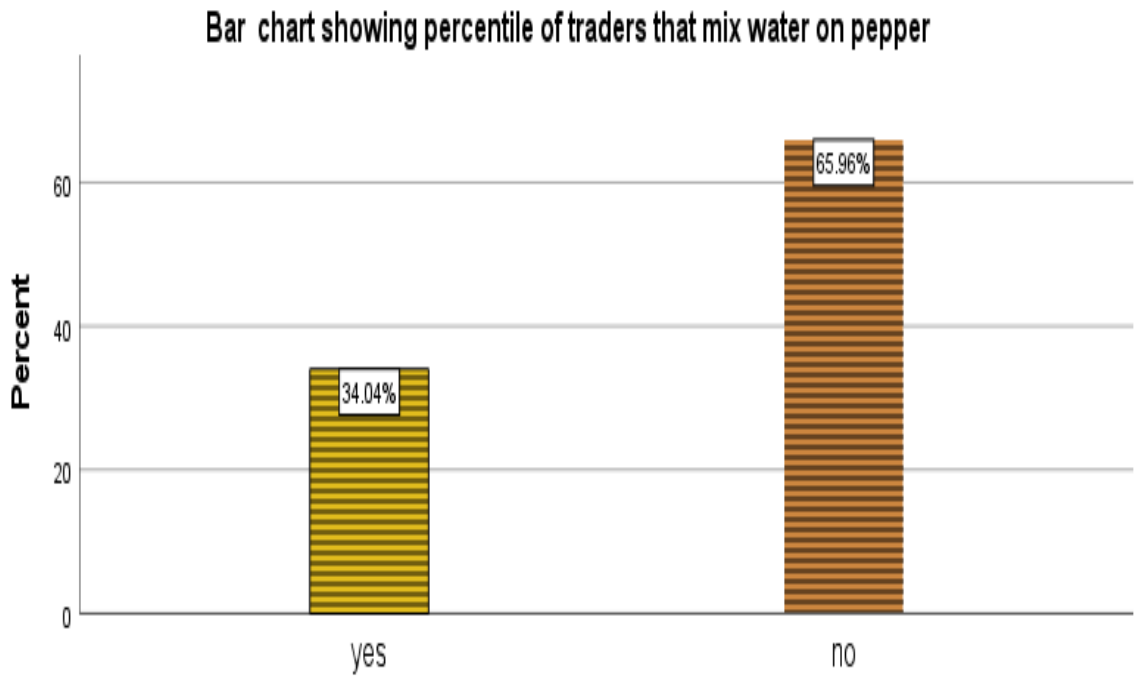
4. Do you get quality pepper in fair price?

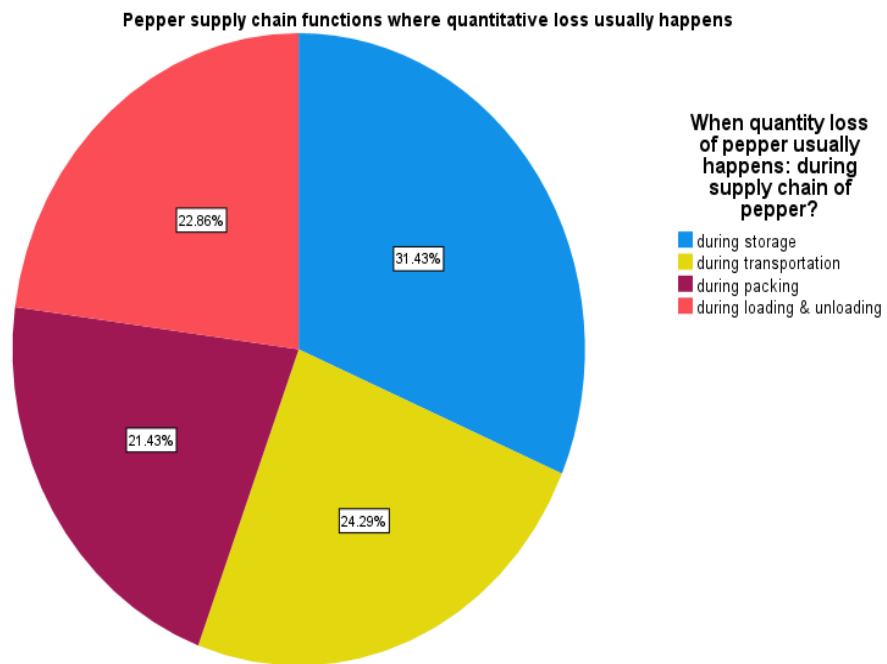
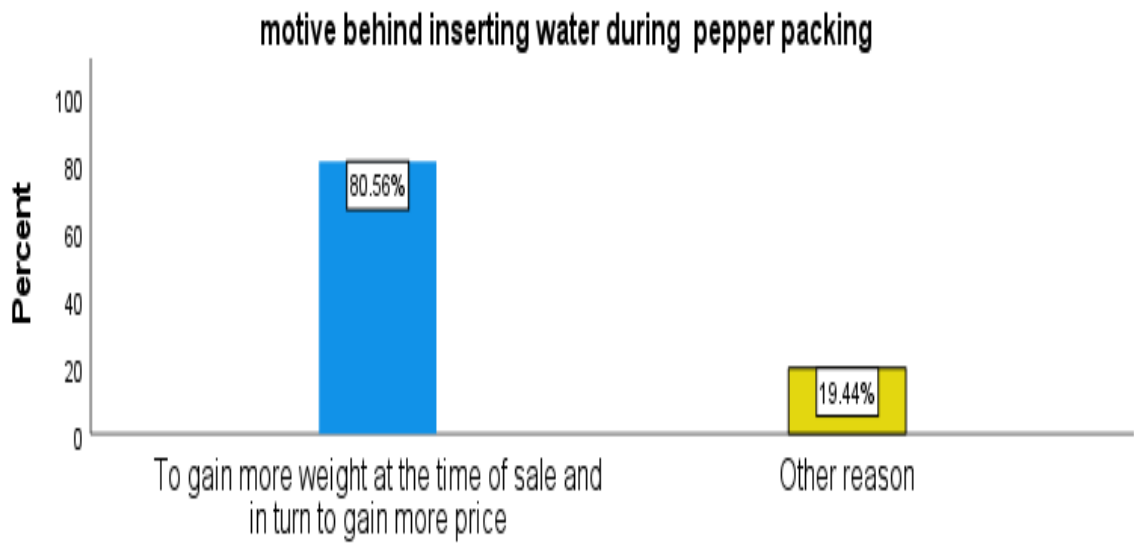
5. If no what are the reasons?

6. From where do you get information about Halaba Pepper sellers?

III. Questionnaire Results







IV. Questionnaire Analysis Inputs

I, Table of confidence label

t Table

cum. prob	$t_{.50}$	$t_{.75}$	$t_{.80}$	$t_{.85}$	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$	$t_{.999}$	$t_{.9995}$
one-tail	0.50	0.25	0.20	0.15	0.10	0.05	0.025	0.01	0.005	0.001	0.0005
two-tails	1.00	0.50	0.40	0.30	0.20	0.10	0.05	0.02	0.01	0.002	0.001
df											
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.31	636.62
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.327	31.599
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.215	12.924
4	0.000	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.000	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.000	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.000	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.000	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.000	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	0.000	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	0.000	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	0.000	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	0.000	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	0.000	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.787	4.140
15	0.000	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	0.000	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	0.000	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	0.000	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	0.000	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.579	3.883
20	0.000	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.552	3.850
21	0.000	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	0.000	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	0.000	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.485	3.768
24	0.000	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.467	3.745
25	0.000	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.450	3.725
26	0.000	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	0.000	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	0.000	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	0.000	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.396	3.659
30	0.000	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.385	3.646
40	0.000	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.307	3.551
60	0.000	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	3.232	3.460
80	0.000	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	3.195	3.416
100	0.000	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	3.174	3.390
1000	0.000	0.675	0.842	1.037	1.282	1.646	1.962	2.330	2.581	3.098	3.300
Z	0.000	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.291
	0%	50%	60%	70%	80%	90%	95%	98%	99%	99.8%	99.9%
	Confidence Level										

Critical Values for Pearson's Correlation Coefficient

DF	Proportion in ONE Tail					
	.25	.10	.05	.025	.01	.005
	Proportion in TWO Tails					
	.50	.20	.10	.05	.02	.01
51	.0947	.1789	.2284	.2706	.3188	.3509
52	.0938	.1772	.2262	.2681	.3158	.3477
53	.0929	.1755	.2241	.2656	.3129	.3445
54	.0920	.1739	.2221	.2632	.3102	.3415
55	.0912	.1723	.2201	.2609	.3074	.3385
56	.0904	.1708	.2181	.2586	.3048	.3357
57	.0896	.1693	.2162	.2564	.3022	.3328
58	.0888	.1678	.2144	.2542	.2997	.3301
59	.0880	.1664	.2126	.2521	.2972	.3274
60	.0873	.1650	.2108	.2500	.2948	.3248
61	.0866	.1636	.2091	.2480	.2925	.3223
62	.0858	.1623	.2075	.2461	.2902	.3198
63	.0852	.1610	.2058	.2441	.2880	.3173
64	.0845	.1598	.2042	.2423	.2858	.3150
65	.0838	.1586	.2027	.2404	.2837	.3126
66	.0832	.1574	.2012	.2387	.2816	.3104
67	.0826	.1562	.1997	.2369	.2796	.3081
68	.0820	.1550	.1982	.2352	.2776	.3060
69	.0814	.1539	.1968	.2335	.2756	.3038
70	.0808	.1528	.1954	.2319	.2737	.3017
71	.0802	.1517	.1940	.2303	.2718	.2997
72	.0796	.1507	.1927	.2287	.2700	.2977
73	.0791	.1497	.1914	.2272	.2682	.2957
74	.0786	.1486	.1901	.2257	.2664	.2938
75	.0780	.1477	.1888	.2242	.2647	.2919
76	.0775	.1467	.1876	.2227	.2630	.2900
77	.0770	.1457	.1864	.2213	.2613	.2882
78	.0765	.1448	.1852	.2199	.2597	.2864
79	.0760	.1439	.1841	.2185	.2581	.2847
80	.0755	.1430	.1829	.2172	.2565	.2830
81	.0751	.1421	.1818	.2159	.2550	.2813
82	.0746	.1412	.1807	.2146	.2535	.2796
83	.0742	.1404	.1796	.2133	.2520	.2780
84	.0737	.1396	.1786	.2120	.2505	.2764
85	.0733	.1387	.1775	.2108	.2491	.2748
86	.0728	.1379	.1765	.2096	.2477	.2732
87	.0724	.1371	.1755	.2084	.2463	.2717
88	.0720	.1364	.1745	.2072	.2449	.2702
89	.0716	.1356	.1735	.2061	.2435	.2687
90	.0712	.1348	.1726	.2050	.2422	.2673

Modeling post-harvest logistics operation of pepper: a case of Halaba Zone

V, Questioner of farmers' validity test result of spss using Pearson correlation

		Correlations											
		What is common problem you face during pepper transportation from farm to store as well to market?	What was your commonly used material handling equipment?	How did you transport pepper from farm to home as well to market?	Do you encounter loss of pepper during transportation?	If yes what are the common cause of loss of pepper?	Did you store pepper after production in 2019/20?	If yes: how long did you store, in months?	How did you store the pepper?	What were common problem you encounter during storage?	Was there any change in the quantity (weight) and quality of the stored pepper?	What was common problems you faced during pepper marketing?	total
What is common problem you face during pepper transportation from farm to store as well to market?	Pearson Correlation	1	.072	.146	.105	.147	-.201	-.045	.076	.106	.059	-.001	.286 ^{**}
	N	70	69	70	70	70	70	70	70	70	70	70	69
What was your commonly used material handling equipment?	Pearson Correlation	.072	1	.094	.070	.020	.058	-.070	-.025	.179	.293 ^{**}	.029	.415 ^{**}
	Sig. (2-tailed)	.555		.438	.566	.873	.634	.563	.836	.139	.014	.810	<.001
	N	69	70	70	70	70	70	70	70	70	70	70	69
How did you transport pepper from farm to home as well to market?	Pearson Correlation	.146	.094	1	.162	.095	.063	.076	.152	-.053	-.138	.160	.445 ^{**}
	Sig. (2-tailed)	.227	.438		.178	.429	.600	.517	.207	.660	.253	.162	<.001
	N	70	70	71	71	71	71	71	71	71	71	71	69
Do you encounter loss of pepper during transportation?	Pearson Correlation	.105	.070	.162	1	.095	.172	.119	.300 ^{**}	.083	.066	-.130	.321 ^{**}
	Sig. (2-tailed)	.386	.566	.178		.426	.148	.320	.010	.489	.580	.275	.007
	N	70	70	71	72	72	72	72	72	72	72	72	69
If yes what are the common cause of loss of pepper?	Pearson Correlation	.147	.020	.095	.095	1	.065	-.133	.067	.044	.089	.071	.410 ^{**}
	Sig. (2-tailed)	.225	.873	.429	.426		.587	.266	.574	.713	.458	.552	<.001
	N	70	70	71	72	72	72	72	72	72	72	72	69
Did you store pepper after production in 2019/20?	Pearson Correlation	-.201	.058	.063	.172	.065	1	.066	.043	.029	.154	.281 ^{**}	.332 ^{**}
	Sig. (2-tailed)	.095	.634	.600	.148	.587		.583	.720	.808	.197	.017	.005
	N	70	70	71	72	72	72	72	72	72	72	72	69
If yes: how long did you store, in months?	Pearson Correlation	-.045	-.070	.076	.119	-.133	.066	1	.034	-.220	.172	.072	.326 ^{**}
	Sig. (2-tailed)	.711	.563	.517	.320	.266	.583		.777	.063	.149	.548	.006
	N	70	70	71	72	72	72	72	72	72	72	72	69
How did you store the pepper?	Pearson Correlation	.076	-.025	.152	.300 ^{**}	.067	.043	.034	1	.271 ^{**}	-.040	-.048	.387 ^{**}
	Sig. (2-tailed)	.533	.836	.207	.010	.574	.720	.777		.021	.740	.683	.001
	N	70	70	71	72	72	72	72	72	72	72	72	69
What were common problem you encounter during storage?	Pearson Correlation	.106	.179	-.053	.083	.044	.029	-.220	.271 ^{**}	1	.050	.022	.330 ^{**}
	Sig. (2-tailed)	.384	.139	.660	.489	.713	.808	.063	.021		.674	.654	.006
	N	70	70	71	72	72	72	72	72	72	72	72	69

VI, Questionnaire of traders' validity test result of spss using Pearson correlation

		Correlations									
		How did you transport pepper from home (warehouse) to market? » How did you transport pepper from home (warehouse) to market? »	What did you do, when the pepper you offered to the market was not sold?	. What was your packaging material when you sold?	Do you insert water in time of packing?	If yes what were your motive?	Are you satisfied in warehouse service?	If no what were your reason?	Was there any change in the quantity (weight) and quality of the stored pepper?	When quantity loss of pepper usually happens: during supply chain of pepper?	TradersQ
How did you transport pepper from home (warehouse) to market? » How did you transport pepper from home (warehouse) to market? »	Pearson Correlation	1	.199	.120	-.024	-.006	.009	.049	.160	-.063	.391 ^{**}
	Sig. (2-tailed)		.097	.318	.871	.971	.947	.715	.185	.607	.030
	N	73	71	71	47	36	62	58	70	70	31
What did you do, when the pepper you offered to the market was not sold?	Pearson Correlation	.199	1	.071	-.189	.053	.015	.244	.156	-.189	.454 ^{**}
	Sig. (2-tailed)	.097		.556	.208	.762	.908	.065	.205	.122	.010
	N	71	72	71	46	35	62	58	68	68	31
. What was your packaging material when you sold?	Pearson Correlation	.120	.071	1	.096	-.008	-.052	-.038	-.031	-.101	.325
	Sig. (2-tailed)	.318	.556		.521	.964	.693	.780	.802	.411	.075
	N	71	71	72	47	36	61	57	68	68	31
Do you insert water in time of packing?	Pearson Correlation	-.024	-.189	.096	1	.157	-.117	-.044	.057	.027	.207
	Sig. (2-tailed)	.871	.208	.521		.361	.448	.786	.705	.858	.285
	N	47	46	47	47	36	44	41	47	45	31
If yes what were your motive?	Pearson Correlation	-.006	.053	-.008	.157	1	.268	.326	.478 ^{**}	-.209	.500 ^{**}
	Sig. (2-tailed)	.971	.762	.964	.361		.120	.069	.003	.227	.004
	N	36	35	36	36	36	35	32	36	35	31
Are you satisfied in warehouse service?	Pearson Correlation	.009	.015	-.052	-.117	.268	1	.090	-.038	.192	.225
	Sig. (2-tailed)	.947	.908	.693	.448	.120		.502	.771	.146	.223
	N	62	62	61	44	35	62	58	61	59	31
If no what were your reason?	Pearson Correlation	.049	.244	-.038	-.044	.326	.090	1	-.052	.041	.609 ^{**}
	Sig. (2-tailed)	.715	.065	.780	.786	.069	.502		.698	.769	<.001
	N	58	58	57	41	32	58	58	57	55	31
Was there any change in the quantity (weight) and quality of the stored pepper?	Pearson Correlation	.160	.156	-.031	.057	.478 ^{**}	-.038	-.052	1	.062	.521 ^{**}
	Sig. (2-tailed)	.185	.205	.802	.705	.003	.771	.698		.619	.003
	N	70	68	68	47	36	61	57	70	67	31

VII. Frequencies of questionnaire

I. Frequencies of farmers' questionnaire

Question number	Questions	N=90	
		Valid	Missing
Q1	What was common problem you face during pepper transportation from farm to store as well to market?	70	20
Q2	What was your commonly used material handling equipment?	70	20
Q3	How did you transport pepper from farm to home as well to market?	71	19
Q4	How did you transport pepper from farm to home as well to market?	72	18
Q5	If yes what are the common cause of loss of pepper?	72	18
Q6	Did you store pepper after production in 2019/20?	72	18
Q7	If yes: how long did you store, in months?	72	18
Q8	How did you store the pepper?	72	18
Q9	What were common problem you encounter during storage?	72	18
Q10	Was there any change in the quantity (weight) and quality of the stored pepper?	72	18
Q11	.What was common problems you faced during pepper marketing?	72	18

VIII. Frequencies of traders questionnaire

Question Number	Questions	N=88	
Q1	How did you transport pepper from home (warehouse) to market?		
Q2	What did you do, when the pepper you offered to the market was not sold?		
Q3	What was your packaging material when you sold?		
Q4	Do you insert water in time of packing?		
Q5	If yes what were your motive?		
Q6	Are you satisfied in warehouse service?		
Q7	If no what were your reason?		
Q8	Was there any change in the quantity (weight) and quality of the stored pepper?		
Q9	When quantity loss of pepper usually happens: during supply chain of pepper?		

Appendix 2

Summary of literature review conducted

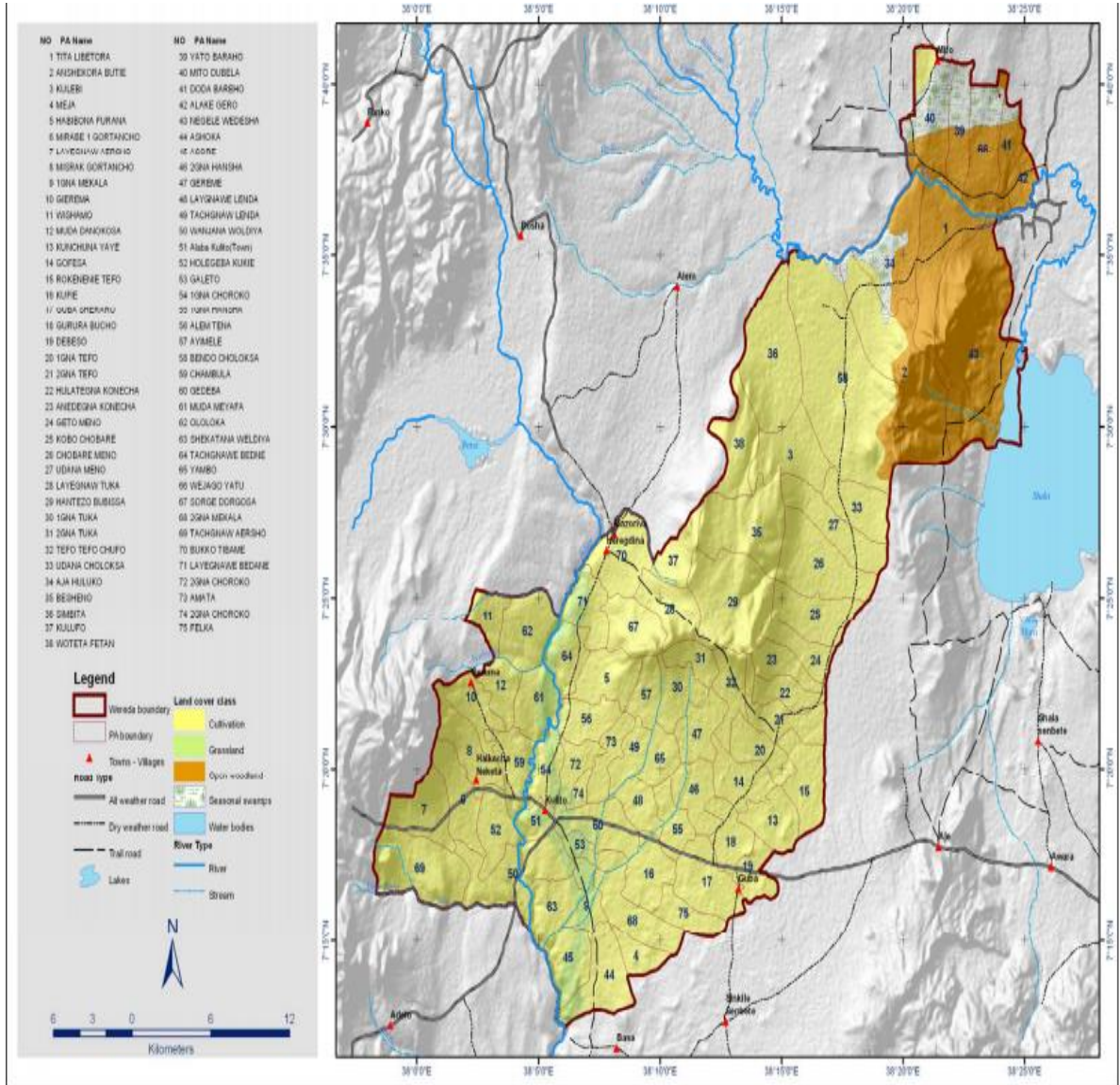
Article	Objectives	Period		Stage		Demand		Capacity		Model	Solution Method		
		Single	Multiple	Single	Multiple	Stochastic	Deterministic	Capacitated	Un capacitated		Exact	Heuristic	Hybrid
(Bidhandi et al., 2009)	Total costs	✓			✓		✓	✓		MILP	✓		
(Sahyouni et al., 2007)	Total costs	✓		✓			✓		✓	MILP	✓		
(Üster, Easwaran, Akçali, & Çetinkaya, 2007)	Total costs	✓			✓		✓		✓	MILP	✓		
(Pishvae & Torabi,	Total costs Total delivery	✓			✓		✓	✓		MOPMI LP			✓

2010)	Tardiness												
(Lu & Bostel, 2007)	Total costs	✓		✓		✓		✓		MILP			✓
(Ko & Evans, 2007)	Total costs		✓	✓		✓		✓		MINLP			✓
(Pishvae & Rabbani, 2011)	Total costs	✓		✓		✓	✓			MILP			✓
(Wang, Lai, & Shi, 2011)	Total costs&Total co2 emission	✓				✓	✓			MILP	✓		
(Du & Evans, 2008)	Total costs Total tardiness of cycle time	✓		✓		✓	✓			MILP			
(Lee & Dong, 2008)	Total costs	✓		✓		✓	✓			MILP			
(Lieckens &)	Profit maximization	✓		✓	✓		✓			MINLP			

Vandaele, 2007)													
(Nickel et al., 2012)	Financial benefit		✓		✓	✓				MIP		✓	
(Yu & Solvang, 2017)	Gov't subsidies, Global warming, Profit maximization	✓			✓		✓	✓		MILP			✓
Fattahi & Govindan, 2017)	Maximize the net income		✓		✓	✓		✓		MILP			✓
(Soleimani & Govindan, 2014)	Profit maximization, Conditional value at risk	✓			✓	✓		✓		MILP			

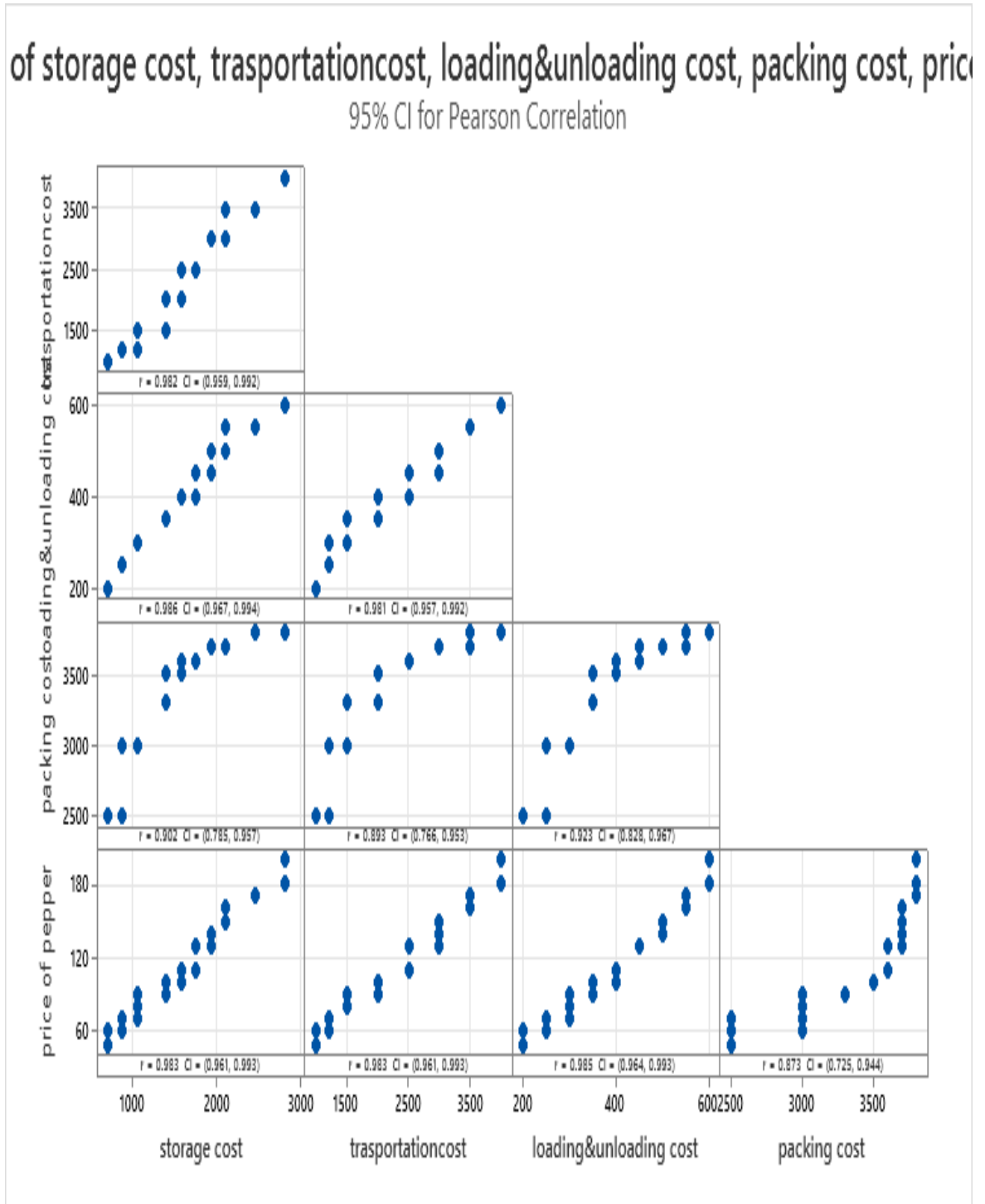
Appendix 3

Geographical Map of Halaba zone



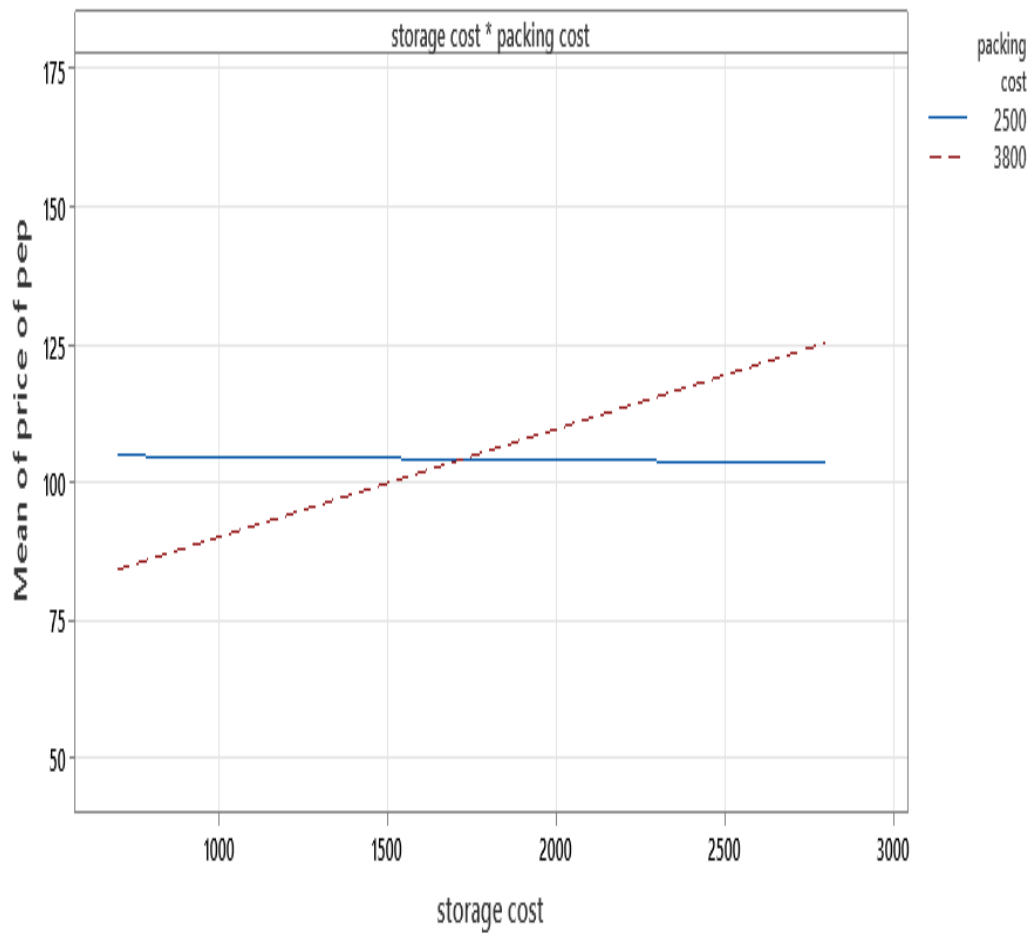
Appendix 4

Regression Result

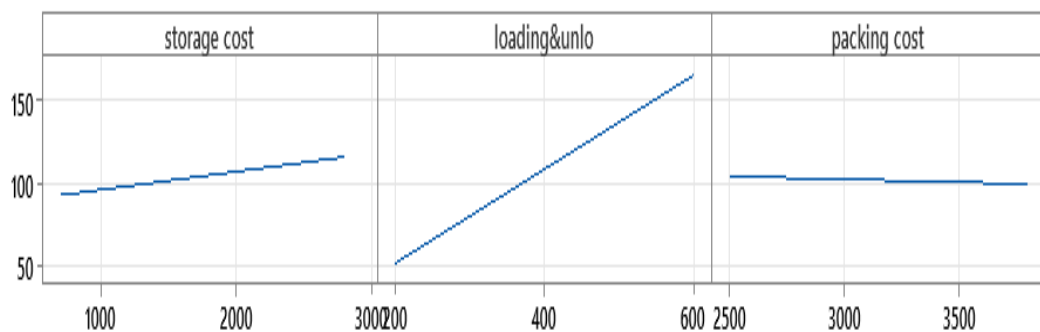


Multiple Regression for price of pep Effects Report

Interaction Plots for price of pep
Describes how price of pep changes if you change the settings of two X variables.



Main Effects Plots for price of pep
Describes how price of pep changes if you change the settings of one X variable.
If there is an interaction between X variables, use the interaction plots to determine the best variable settings.



Multiple Regression for price of pep Model Building Report

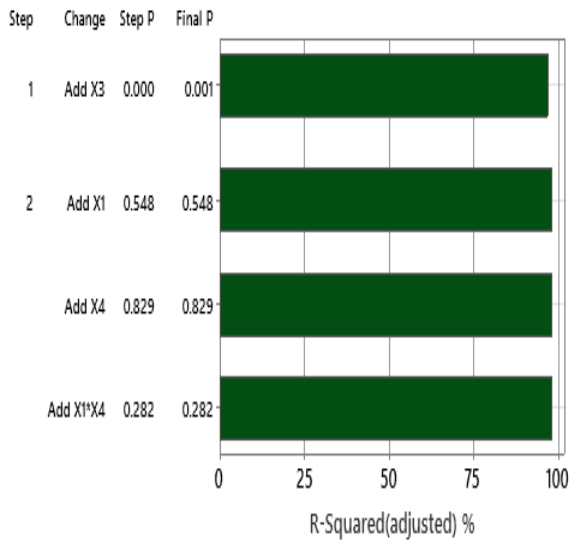
X1: storage cost X2: trasportatio X3: loading&unlo X4: packing cost

Final Model Equation

$$\text{price of pe} = 64.3 - 0.0394 X1 + 0.2871 X3 - 0.02671 X4 + 0.000016 X1 * X4$$

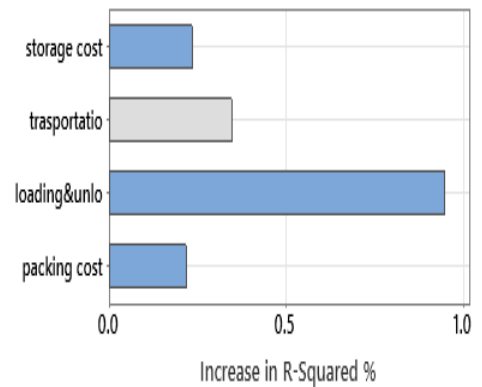
Model Building Sequence

Displays the order in which terms were added or removed.



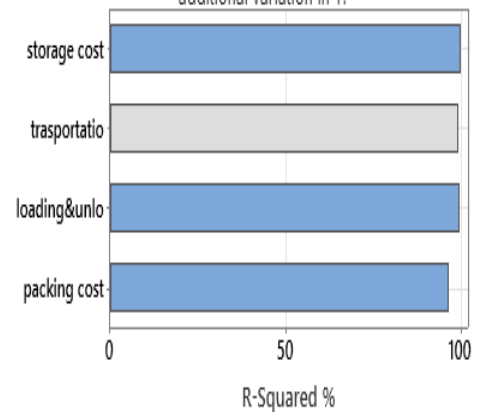
Incremental Impact of X Variables

Long bars represent Xs that contribute the most new information to the model.



Each X Regressed on All Other Terms

Gray bars represent Xs that do not help explain additional variation in Y.



A gray bar represents an X variable not in the model.

Appendix 5

Excel Data analysis for Pareto

week	P1(storage cost)	P2(transportation cost)	P3(loading and unloading cost)	P4 (packing)	sum total	%p1	%p2	%p3	%p4	sum(%p1+% p3)	sum (%p2+%p4)	Weekly pepper price
1	700	1000	200	2500	4400	15.91	22.73	4.55	56.82	20.45	79.55	50
2	700	1000	200	2500	4400	15.91	22.73	4.55	56.82	20.45	79.55	60
3	700	1000	200	2500	4400	15.91	22.73	4.55	56.82	20.45	79.55	50
4	875	1200	250	2500	4825	18.13	24.87	5.18	51.81	23.32	76.68	70
5	875	1200	250	2500	4825	18.13	24.87	5.18	51.81	23.32	76.68	70
6	875	1200	250	3000	5325	16.43	22.54	4.69	56.34	21.13	78.87	60
7	1050	1200	300	3000	5550	18.92	21.62	5.41	54.05	24.32	75.68	70
8	1050	1500	300	3000	5850	17.95	25.64	5.13	51.28	23.08	76.92	80
9	1050	1500	300	3000	5850	17.95	25.64	5.13	51.28	23.08	76.92	80
10	1050	1500	300	3000	5850	17.95	25.64	5.13	51.28	23.08	76.92	90
11	1400	1500	350	3000	6250	22.40	24.00	5.60	48.00	28.00	72.00	90
12	1400	2000	350	3300	7050	19.86	28.37	4.96	46.81	24.82	75.18	90
13	1400	2000	350	3300	7050	19.86	28.37	4.96	46.81	24.82	75.18	100
14	1575	2000	400	3500	7475	21.07	26.76	5.35	46.82	26.42	73.58	100
15	1575	2500	400	3500	7975	19.75	31.35	5.02	43.89	24.76	75.24	110
16	1750	2500	400	3600	8250	21.21	30.30	4.85	43.64	26.06	73.94	110
17	1750	2500	450	3600	8300	21.08	30.12	5.42	43.37	26.51	73.49	130
18	1925	3000	450	3700	9075	21.21	33.06	4.96	40.77	26.17	73.83	130
19	1925	3000	500	3700	9125	21.10	32.88	5.48	40.55	26.58	73.42	140
20	2100	3000	500	3700	9300	22.58	32.26	5.38	39.78	27.96	72.04	150
21	2100	3500	550	3700	9850	21.32	35.53	5.58	37.56	26.90	73.10	160
22	2450	3500	550	3800	10300	23.79	33.98	5.34	36.89	29.13	70.87	170
23	2800	4000	600	3800	11200	25.00	35.71	5.36	33.93	30.36	69.64	180
24	2800	4000	600	3800	11200	25.00	35.71	5.36	33.93	30.36	69.64	200

Appendix 6
Survey captures



Storage condition in Halaba Kulito warehouses



Poor packing: over filled sack that drops pepper pcs

II, Different Quality Peppers



Sample of best quality pepper called Zala



Medium quality pepper called KEYITALA

Sample of least quality pepper



Weekly sales price of pepper announcement Board

III, Transportation Means of Halaba pepper



IV, marketing of pepper in Halaba Kulito Town

