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Food Supply Chain Design: Case study (MEAD Food Complex Share Company Debere Marekos)

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PRODUCTION ENGINEERING AND MANAGEMENT

Food Supply Chain Design: Case study (MEAD Food Complex Share Company Debere Marekos)

BY

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B.SC in Industrial Engineering Bahir Dar Institute of Technology, 2014

A Thesis Submitted In Partial Fulfillment of the Requirement for the Degree of Masters of Science in Production Engineering and Management

Thesis Advisor: Betsiha Tizazu (Dr)

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I hereby confirm that the change required by the examiners have been carried out and incorporated in the final thesis.

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We hereby certify that the thesis is accepted for Fulfillment of the Requirement for award of the Degree of Masters of Science in "production Engineering and Management in faculty of Mechanical and Industrial Engineering".

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DECLARATION

I hereby declare that work which is being presented in this thesis entitle “food supply chain network design using Multi criteria decision making technique analysis in case of Maed food complex” is original work of my own, has not been presented for a degree of any other university and all the resources of materials used for the thesis have been properly acknowledged.

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Betsiha Tizazu (Dr)

Advisor   Date

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Abbreviation

AHP	Analytic Hierarchy Process
MCDM	Multi-criteria decision making
SCA	Supply Chain Analytics
SCD	Supply Chain Design
SCM	Supply Chain Management
SCN	Supply Chain Network
CSA	Central Statistics Authority of Ethiopia

ABSTRACT

The primary objective of this study is to design optimal food supply chain network for Maed food complex share company. On these premise the study investigates the optimal location of retailer to minimize cost and designing suitable design of distribution center. The study utilizes for transportation system and location identification and also to determine the optimal decision and solve transportation model decision making formulated model. The raw material and finished production of transportation model to find the minimum cost of a linear transportation type and represented as transportation tableau which was solved initial basic feasible solution and optimal solution. From the results of the analysis, it is shown that all three methods of initial basic feasible The North-West corner method gave transportation cost of 255,565,221.286 ETB, Least Cost (minimum) method gave transportation cost of 385,801,916.946 ETB and Vogel Approximation method gave 238,141,200.6555 ETB as its transportation cost. The above result shows that Vogel Approximation method is the most efficient of initial basic solution all the methods because it has the least transportation cost, from start this result to calculate more optimal solution by using An MODI Method – UV Method gave 238,141,200.6555.

From the optimization of the cost by MODI method-UV method. From the result and discussion part the facility location is selected at Deremarkos using different criteria.

The main suppliers for the company are east Gojam, south wello, North Shewa and south Gondar. Proposed destinations for raw material are Debre Elias, Debre Birihan and Bahir Dar. Having those destinations the transportation model result reveals 244,731.89 tone and 16,814.85 tone supply from east gojam to Debre elias and Debre Birhan respectively. South wello supply 46,450.6389 tone, and 107,422.6111 tons, raw material to Debre Birhan and ,Bahir Dar respectively. South Gondar supply 120,494.4167 ton raw material to Bahir Dar. The final supplier which is North Shewa supply 114,281.25 tone to Debre Birhan and 84,000 tone somewhere or may be store at company inventory by zero cost at the minimum cost of transportation of 238,141,200.6555 ETB.

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CHAPTER ONE

1. Introduction

1.1. Background justification

In recent years, numerous approaches have been proposed to improve manufacturing operations performance. Among many others, supply chain management has received considerable attentions. Despite its benefits, structuring supply chain (SC) network is a complex decision making process. At strategic level companies have to decide where to locate new facilities, how to allocate resources to the various facilities, and how to manage the transportation of products through the chain in order to satisfy customer demands.

Transportation Combined with Network Design, in food industry; there exist many kinds of distribution networks. In practice, the network design problem is to jointly optimize the location of hubs and the flows from upstream manufacturers to downstream retailers and customers. Distribution network design plays a key role in reducing transportation costs and maintaining quality of perishable products in food supply chains. Network design projects are quite extensive and are always made on a strategic level. Analytics strategically contribute in identifying the number, location, size, and capacity of the facilities (e.g. warehouses, plants, distribution centers)

For a long period of time, there has been an increasing interest in the use of supply chain methods to improve performance across the entire business enterprise. A supply chain is an integrated process in which a number of different corporate entities (such as suppliers, manufacturers, distributors, and retailers) collaborate to: acquire raw materials, convert these raw m The nature of the supply chain is shaped by supply chain design, which ultimately consists of the decisions that impact the firm's investment patterns throughout its numerous supplier networks. Nel & Badenhorst-Weiss, (2010) also defined a supply chain as a group of at least three organizations that are directly linked by supply chain activities (or supply chain flows) between an organization, a supplier to the organization, and an organization's customer.

Beamon, (1998) also confirmed that a supply chain is an integrated manufacturing process that involves converting raw materials into finished goods and then delivering them to clients.

A supply chain is made up of two fundamental, interconnected activities at its most basic level: the first is production planning and inventory control, and the second is distribution and logistics. Diagrammatically, arterials into specified final products, and deliver these final products to retailers (Habib, 2011).

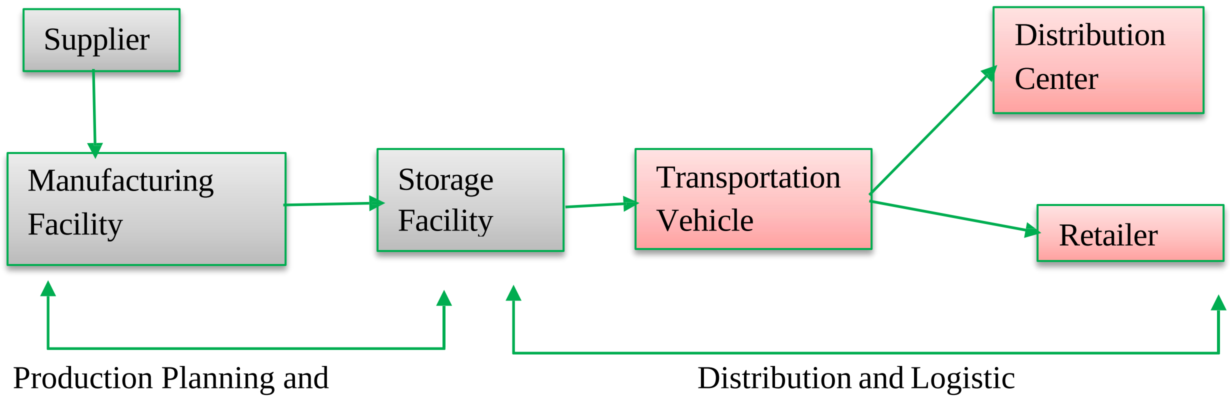

Figure 1.1: The supply chain process

According to Habib, (2011) defined supply chain as network of companies engaging in various processes and activities that generate value in the form of products and services in the hands of the end customer through downstream and upstream relationships.

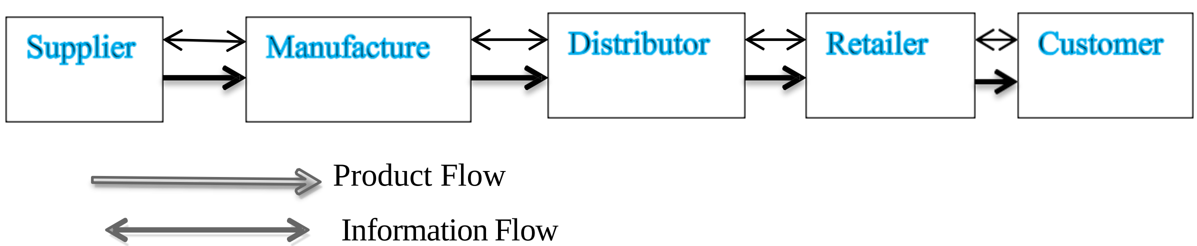

Figure 1.2: The basic supply chain (Habib, 2011)

As you see from the diagram supply chain consists of manufacturer, supplier, distributor, retailer andfinal customer (Felea & Albăstroiu, 2013).

Supply chain design (SCD) will become a crucial source of competitive advantage as rivalry evolves from competition between organizations to competition between supply chains. It will be a critical aspect in determining the efficiency and effectiveness of a supply chain in an enterprise (Nel & Badenhorst-Weiss, 2010). Since, to be successful in increasing globalized and competitive market, companies must constantly strive to reduce supply chain costs and improve customer service while planning for the unexpected (Teklay, 2017). Supply chain design incorporates different factor from this unexpected and unplanned occasion, geographical distance, governmental issue and others. This makes supply chain network design disruption, which means disruption implies important activator, leads to the occurrence of risk (Abushaega, 2016).

Having this disturbance or problem the objective the researcher is to create a supply chain network that operates efficiently at the lowest possible cost, in normal and disrupted situations.

The formulation of relevant performance measurements is a crucial part of supply chain design and analysis.According to Beamon, (1998) categorized as qualitative and quantitative performance measure. Although certain parts of qualitative performance indicators may be quantified, there is no single direct numerical measurement for them. Such as customer satisfaction, flexibility, information and material flow integration, effective risk management and supplier performance. But the measurements that may be directly stated quantitatively are known as quantitative performance measures. According to (Anand & Pandian,2019) transportation play an important role (one component) in SC operations. When shipping charges are included in, accessible substitute selections lower the overall cost of the SC estimate.

1.2. Transportation model

The transportation problem is one of the subclasses of linear programming problem where the objective is to transport various quantities of a homogeneous product that are initially stored at various origins, to different destinations in such a way that the total transportation cost is at its minimum. Transportation models or problems are primarily concerned with the optimal (best possible) way in which a product produced at different factories or plants (called supply origins) can be transported to a number of warehouses (called demand destinations). The objective in a transportation problem is to fully satisfy the destination requirements within the operating production capacity constraints at the minimum possible cost. Whenever there is a physical movement of goods from the point of manufacture to the final consumers through a variety of channels of distribution (wholesalers, retailers, distributors etc.), there is a need to Minimize the cost of transportation so as to increase the profit on sales.

1.3. Background of Food Processing Industry

The Food Industry in Ethiopia is one of the fastest growing industries amid growing population and urbanization. The value added in the national account concept that contributes approximately 33% gross value of production realized by manufacturing sector as a whole (CSA Report, 2010/2011). Out of a total number of 2170 operating industrial enterprises reported by the Central Statistics Authority of Ethiopia (CSA: 2010/2011), about 686 are in the food sectors. Generally, the food industry operates at a small-scale level -mainly on manufacturing of grain mill products, bakery products, and prepared foods. The average annual compound rate of growth recorded in food-manufacturing over the decade was about 15% in 2010/2011 (CSA Report, 2010/2011).

Food marketing system involves all activities involved in the flows of food products and services right from the point of production to the point of consumption. The marketing of agricultural products encompasses a complex network of activities that involves a number of intermediaries such as middlemen, facilitating organizations, consumers, food processors, regulators, etc. The flows of processed food products from the point of production to that of consumptions demands a series of actions and events that take places in some sequence, and some form of coordination of this series of events and activities in some orderly fashion. During the nineteenth century numerous improvements were made in mill technology. The demand-supply gap for wheat flour, pasta, macaroni and biscuits are big and there will be a significant unsatisfied demand for flour in the manufacturing sector which uses wheat flour as an input and at household level. In addition, the demand for pasta and macaroni registered a growth rate of 33%, 31%, 6%, 23% and 18% in the year 2001,2002,2003,2004 and 2005 respectively. Furthermore, the demand for biscuits registered annual growth rate of 14%, 23%, 32%, 34%, and 21% in the year 2001, 2002, 2003, 2004 and 2005 respectively. The trends show an average annual increment of 24.8 % and 20.8% per annum for pasta, macaroni and biscuits respectively. It is forecasted to increase the years to come as the economy is expected to continuously grow in double digits for the foreseeable future. Taking this in to consideration, NIGAT Corporate decided for the establishment of food complex including wheat flour, pasta and biscuits processing factory. The company needs Feasibility study to assess the viability of the investment in food complex. But, this study specifically focuses on food supply chain network design.

1.4. Problem Statement

Mead food complex company only studies the feasibility location of raw material of supply chain which get in Amhara region location, the raw materials of the company flow was such that it was collected by local trader and high involvement of brokers from farmers, after passes along chain with complicity then to reaches company, high Cost of transportation as well as other criteria of raw materials such as quality, order of time and demand did not remain the same for every transport situation.

The raw material of wheat supplier sector faces different problems that include poor product quality, lack of market information and price instability are reported as major problems .The existing model in company approximately cost about more than 387,092,370.25 birr in addition to ignore other best quality of raw material, the costs (transportation costs in particular) are too high and actions take too much time. With the rapid growth of the company in mind, Optimization of these processes is needed to make the company ready for the futures; the company needs more improved model.

Supply chain has become a major component of competitive strategy to enhance organizational productivity and profitability (Teklay, 2017). Decisions regarding the SCD are therefore crucial in an organization. Insight of, Johnson et al., (2019) without a doubt, Supply Chain Analytics (SCA) has significant consequences for achieving efficient supply networks, since businesses compete on the basis of their supply networks. The aim of Mead manufacturing company is to minimize cost and meat customer satisfaction. Indirectly it maximizes the overall profit. From the advantage of supply chain, it revenue growth, expense reductions, greater asset utilization, and improved customer service are only the beginning (Zigiaris, 2019).However my research studies to modeling new raw material ware house supply chain system of Mead food complex company by using transportation model making technique to fully satisfy the destination requirements, specifically in which Amhara region with a minimum cost in what optimal amount of raw material , high responsibility ,satisfy customers , and high quality of raw material, as well as to increase the profit on sales ,that found that numerous designs could be feasible for a given set of parameters and assumptions .

1.5. Objectives of the Study

1.5.1. General Objective

The objective of this research is to design new model of food supply chain system by using transportation model in case of Mead Food Complex Company.

1.5.2. Specific Objective

- To observe and evaluate the existing practice of SCM strategy of the Mead Food Complex company.
- To identify number and location of suppliers for Mead Food Complex manufacturing company.
- To modeling new ware house of raw material suppliers of Mead Food Complex manufacturing company by removing the involvement local traders and blockers on existing supply chain
- To formulate and solve transportation model
- To proposed new model of distribution system which generate minim cost and finally to provide a means of designing supply chain network optimization

1.6. Scope of the Study

The main focus area of this research by modeling new improved model food supply chain system for minimizing cost with the case of Mead Food Complex Company at the focus only at the stage of raw material supplier by only improved model of warehouse at suitable location not real design and implementation and also not further calculation transportation cost for production distribution, The researcher wants to study using facility location with transportation method. There are some main products in the company such as produce wheat flour, pasta& macaroni and biscuits.

1.7. Significant of the Study

This thesis provides information on practices and experience of supply chain design, sustainable supply chain system, and mead company food supply chain design. Regarding academic and scientific benefits, this thesis extends the process of designing new supply chain for manufacturing industry particularly mead company by defining the main elements that need to be considered in managing its supply chain, for incurring minimum cost. Overall, this thesis will be a future reference for theoretical and empirical studies of supply chain in Mead Company as well as food industry supply chain.

1.8. Research Organization

The research organized in six chapters

Chapter 1**:** presents the introductory part which includes sections such as background, Problem statement, objectives, research questions, limitations and scope and structure of the study.

Chapter 2**:** presents the literature review on fundamental concepts of food supply chain network, Basic Concepts of Supply Chain.

Chapter 3: outlines the research design and methodology section.

Chapter 4: This section includes data collection, the data type and sources, data processing and analysis and issues of validity and reliability.

Chapter 5: concentrates on the presentation and discussion of the results on of Mead Food Complex Company at the focus only at the stage of raw material supplier by transportation model.

Chapter 6: presents the summary, conclusion, future works and recommendations of the study of minimize costing method and model of warehouse the study.

CHAPTER TWO

2. Literature Review

The literature review part focuses on the papers which are done in the area of supply chain design having theoretical and practical aspects of application and its output. Literature reviewing lends a hand to verify the importance of designing sustainable supply chain to be competitive and profitable and to easily identify the research gap exist between your work and others.

2.1. Basic Concepts of Supply Chain

Supply chain is strategic channel management philosophy composed of the continuous rebuilding of networks of businesses integrated together through information technologies and choice to execute superlative, customer-winning value at the lowest cost through the digital, real-time arrangements of product and services, vital marketplace information, and logistics delivery capabilities with demand priorities. (Ross, 2011).

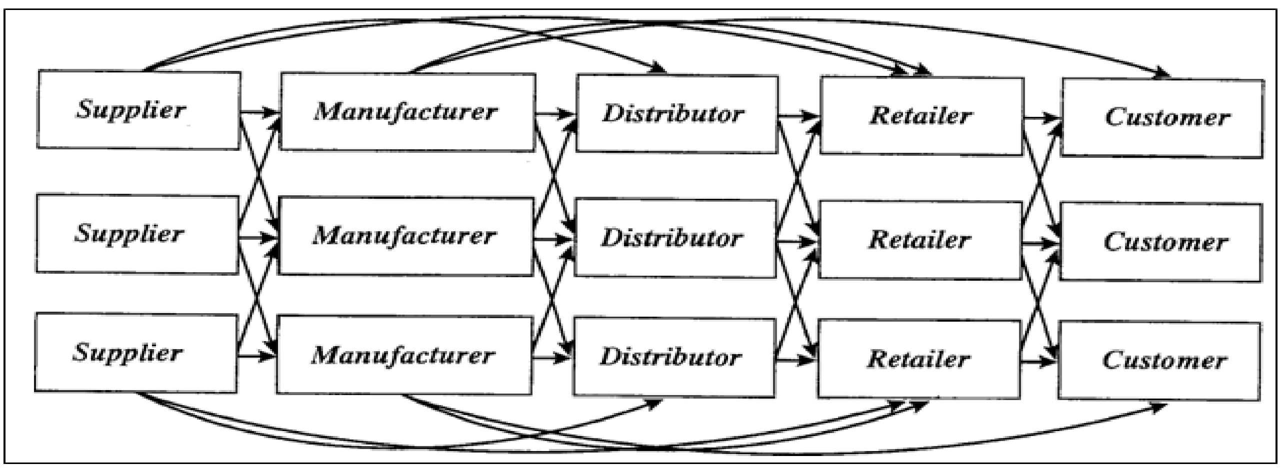

Fig 2.1: supply chain channels

Supply chain network design is the process of establishing network nodes and flow-paths in a supply chain. These nodes can represent either of manufacturing, storing, or distribution locations. This process helps plan the most suitable physical locations and their types that will constitute the supply chain for the most efficient flow of materials and merchandise. An optimally designed network can actually reduce the costs and lead-time for distribution. This is also true for large manufacturers that have sellers, factories, and warehouses distributed across geographies and can benefit from optimizing their net workflow.

2.2. Supply Chain Design

According to the researchers (Woldehanna etal.., 2010) and (Samuel g/Selassie et al.., 2017) the wheat sector faces different problems that include poor product quality, lack of market information and price instability are reported as major problems. The main objective of any manufacturing company is to maximize profit and improve customer satisfaction. But to come with this objective companies add their profit on the overall cost of manufacturing which is traditional way of goal seeking. Source of competitive advantage as rivalry transitions from competition between enterprises to competition between food supply networks, and it will be a critical aspect in determining a supply chain's efficiency and effectiveness (Nel & Badenhorst-Weiss, 2010).

Insight of (Melnyk et al., 2014) defines supply chain design as establishing the firm's intended strategic goals and designing, executing, and managing over time the resources, procedures, and connections (both inside and beyond the supply chain) that strive to make the achievement of those desired results inevitable over time and Supply chain design is critical, strategic and inherently complex. However, supply chain design has its own set of difficulties, concerns, and challenges for managers and academics. Because this idea is still in its early stages, the key questions that determine its content, scope, and bounds are currently being worked out. When it comes to supply chain design, we now understand that "one size does not fit all (Melnyk et al., 2014). Although optimizing SC design and planning is a time-consuming process, it is critical for good supply chain management (Souza Marques Gomes, 2016).

Since, traditional linear supply chains are soon becoming outmoded due to volatile markets, frequently changing customer demands, and persistent ambiguity and unpredictability. Specially, food supply chain design is more complex due to different internal and external factors. These are Perishability, short shelf lives of products, consumer awareness and demand for food attributes such as quality, integrity, and safety, low profit margins, long supply lead times, and increased travel times due to globalization are all factors that add to the complexity of food supply chain management (Souza Marques Gomes, 2016).s, 2010).

According to Sorensen, (2021) for improving the supply chain's architecture in other words, enhancing its stability, cost, and responsiveness at the same time, as dictated by the overall plan.

To obtain these some principles of SCD are:

- ✓ Identify supply chains
- ✓ Identify supply chain partners
- ✓ Distribute activities across the chain
- ✓ Continued monitoring and evaluation

2.3. Supply chain design

According to Sørensen, (2021) from his review researchers design supply chain to reach objectives like sustainable growth, waste minimization, efficiency and responsiveness, minimize cycle time (order and cash), optimization of production capacity, profit maximization and evaluating supply chin performance.

The primary purpose of the existence of any supply chain in any organization is to satisfy customer needs, in the process generating profit for the organization by minimizing the total cost (Habib, 2011). Reasons why nonprofit and profit organizations needed to have supply chain management are promoting consumer happiness, providing quality results, addressing competitive challenges, expanding globalization, increasing relevance of E-commerce, and growing supply chain complexity. But, cost reduction and enhanced customer service are two significant conflicting criteria in supply chain design. The factory and allocation center should be located in a cost-effective area with minimal transportation and construction charges, according to a cost-based supply chain design (Anand & Pandian, 2019). “Network” should replace chain.

All acts related with the movement and transformation of commodities from raw materials to end users, as well as the accompanying information flows, is referred to as supply chain. Up and down the supply chain, materials and information flow (Alemayehu, 2018).

2.4. Barriers of SCM and SCD

Supply chain management necessitates the coordination of numerous activities and flows that span functional and organizational boundaries (Alemayehu, 2018) Reviews uncertainties and an inability to coordinate many activities and partners are the major causes of SCM issues. Most common obstacles are inadequate information sharing, inconsistency in operating goals, organizational culture or structure, poor alliance management practices, a lack of supply chain vision, a lack of managerial commitment, limited resources, and no employee dedication.

2.5. Applications of Supply Chain Design and methods of cost optimization tool

Supply chain design has steadily gained acceptance as a tried-and-true management strategy for attaining long-term profitability and growth. From the revolution of supply chain design it an apply for all manufacturing company and service industry (Habib, 2011).

Table 2.1. ; Benefit and challenges of supply chain from different scholars

	Authors	Benefits of supply chain
Benefit	Ernesto & Roccardo, (2005)	To improved customer service and customer satisfaction, competitive advantage, reduced demand amplification, reduced uncertainties, reduced inventory investment, compressed order-fulfillment cycles, reduced stock levels
	(Anand & Pandian, 2019).	To enhance the optimization of location, inventory, and routing decisions, as well as improved customer service and price reduction
	Sørensen, (2021)	For sustainable growth, waste minimization, efficiency and responsiveness, minimize cycle time (order and cash), optimization of production capacity, profit maximization and Evaluating supply chin performance.
Barriers of SCD	(Meixell, 2005)	Number and location of manufacturing facilities, the amount of capacity at each facility, the assignment of each market area to one or more locations, and supplier selection for sub-Assemblies, components, and materials.
	(Alemayehu, 2018)	Inadequate information sharing, inconsistency in operating goals, organizational culture or structure, poor alliance management practices, a lack of supply chain vision, a lack of managerial commitment, limited resources, and no Employee dedication.

The above table shows that different scholars define the advantage of supply chain. but in this case the researcher emphasis on the primary purpose of the existence of any supply chain in any organization. The researcher wants to pass such challenges when design and implement supply chain for the company. Supply chain design can be apply for all manufacturing company and service industry (Habib, 2011).

2.6. Research gap

About the topic of food supply chain system network development, performance analysis, simulation analysis and Ethiopian wheat value chain there are different published and unpublished literatures. The empirical results of such paper shows the advantages of supply chain design for performance improvement and customer satisfaction. The raw material and semi-finished product of mead food complex company is wheat. But wheat is one of the most challenging agriculture sector in Ethiopia, Some researchers also tries to identify factors affecting supply issues at different functional nodes of Wheat Value Chain, flow of commodities and roles of cooperatives and other institutions in supply issues. Most of researchers made an agreement supply chain design are an important issue for performance improvement and customer responsiveness.

2.7. Transportation method

A general Transportation Model (TM) of the distribution network design is as presented in equation 1. In the equation we get three different models namely: pure linear programming, integer programming and transportation model. The total cost function is the minimum value of sum of fixed plants and warehouses costs (integer programming and linear programming), and transportation cost in supply of raw material and distribution of finished goods (transportation model). This model can locate raw material warehouses for a company. A transportation Model (TM) capturing many practical aspects of network design problems and the optimization techniques, like transportation model, to be used were introduced in this study. The objective is to design the supply chain (SC) network so as to minimize annual system requirements, thereafter increase market share. This is because at current practices most companies do not have a means to sense real situations at their SC. Cost model has been widely adopted to compare total transport costs of several available transport options and multimodal transport. Although the model is useful, it only provides a comparison of freight rates in the available routes. The result provided by the traditional cost model is beneficial for a selection the most appropriate transport route, but not for a decision of where the modal transfer should take place or a comparison of competitiveness of transport modes in a certain route. Transportation problem is a special kind of Linear Programming Problem (LPP) in which goods are transported from a set of sources to a set of destinations subject to the supply and demand of the sources and destination respectively such that the total cost of transportation is minimized. It is also sometimes called as Hitchcock problem.

2.7.1. Types of Transportation problems

Balanced: When both supplies and demands are equal then the problem is said to be a balanced transportation problem.

Unbalanced: When the supply and demand are not equal then it is said to be an unbalanced transportation problem. In this type of problem, either a dummy row or a dummy column is added according to the requirement to make it a balanced problem.

Then it can be solved similar to the balanced problem. Methods to Solve: To find the initial basic feasible solution there are three methods:

- ✓ Northwest Corner Cell Method
- ✓ Least Call Cell Method
- ✓ Vogel's Approximation Method (VAM)

2.7.2. Transportation model for finding a basic feasible Solution

- ➢ Northwest Corner Cell Method

The northwest corner method does not utilize shipping costs, so it can yield an initial feasible solution that has a very high shipping cost. Then determining an optimal solution may require several pivots.

- ➢ The minimum-cost method

Uses the shipping costs in an effort to produce that has a lower total cost. Hopefully, fewer pivots will then be required to find the problem's optimal solution. To begin the minimum-cost method, find the variable with the smallest shipping cost (call it xij). Then assign xij its largest possible value, min {si, dj}. As in the northwest corner method, cross out row i or column j and reduce the supply or demand of the no crossed- out row or column by the value of xij. Then choose from the cells that do not lay in a crossed-out row or column the cell with the minimum shipping cost and repeat the procedure. Continue until there is only one cell that can be chose.

- ➢ Vogel's Method for Finding a Basic Feasible Solution

Begin by computing for each row (and column) a "penalty" equal to the difference between the two smallest costs in the row (column). Next find the row or column with the largest penalty. Choose as the first basic variable the variable in this row or column that has the smallest shipping cost. As described in the northwest corner and minimum- cost methods, make this variable as large as possible, cross out a row or column, and change the supply or demand associated with the basic variable.

Now recomputed new penalties (using only cells that do not lie in a crossed-out row or column), and repeat the procedure until only one uncrossed cell remains. Set this variable equal to the supply or demand associated with the variable, and cross out the variable's row and column. A BFS has now been obtained.

2.8. Transportation model for finding optimal solution

2.8.1. MODI Method – UV Method

There are two phases to solve the transportation problem. In the first phase, the initial basic feasible solution has to be found and the second phase involves optimization of the initial basic feasible solution that was obtained in the first phase. Summary of literature review In today's more volatile economy, the supply chain has emerged as a significant competitive factor during the previous 20 years (Melnyk et al., 2014). The main issue in manufacturing industries is to design optimal supply chain for the purpose of ensuring industries capacity. Since, supply chain effect on their quality and performance of firms. To have good manufacturing system it should be compressive, causally oriented, vertically and horizontally integrated, interlay comparable and useful supply chain. Due to manufacturing companies' problems like shorter product life cycles, complicated corporate joint ventures, and stricter customer service standards, it's critical to evaluate the whole spectrum of supply chain management, from raw material suppliers through factories and warehouses, to demand for a finished product in a shop (Ernesto & Roccardo, 2005).

Supply chain design can be defined as establishing the firm's intended strategic goals and designing, executing, and managing over time the resources, procedures, and connections (both inside and beyond the supply chain) that strive to make the achievement of those desired results inevitable over time and Supply chain design is critical, strategic and inherently complex. The nature of the supply chain is shaped by supply chain design, which ultimately consists of the decisions that impact the firm's investment patterns throughout its numerous supplier networks. These decisions have an impact on the supply chain's capabilities - in other words, the sorts of problems it can and cannot solve (Melnyk et al., 2014).

CHAPTER THREE

3. Methodology

3.1. Introduction

The theory of procedure through which a research is done is known as methodology. Methodological investigations enable the researcher to have a better understanding of prior studies and how to continue them in the future (Ernesto & Roccardo, 2005).

3.1.2. Methodology of the research

Step 1: Identifying logistics key issues, make to conduct analysis on existing supply chain of the company and try to get the main bottle neck of supply chain.

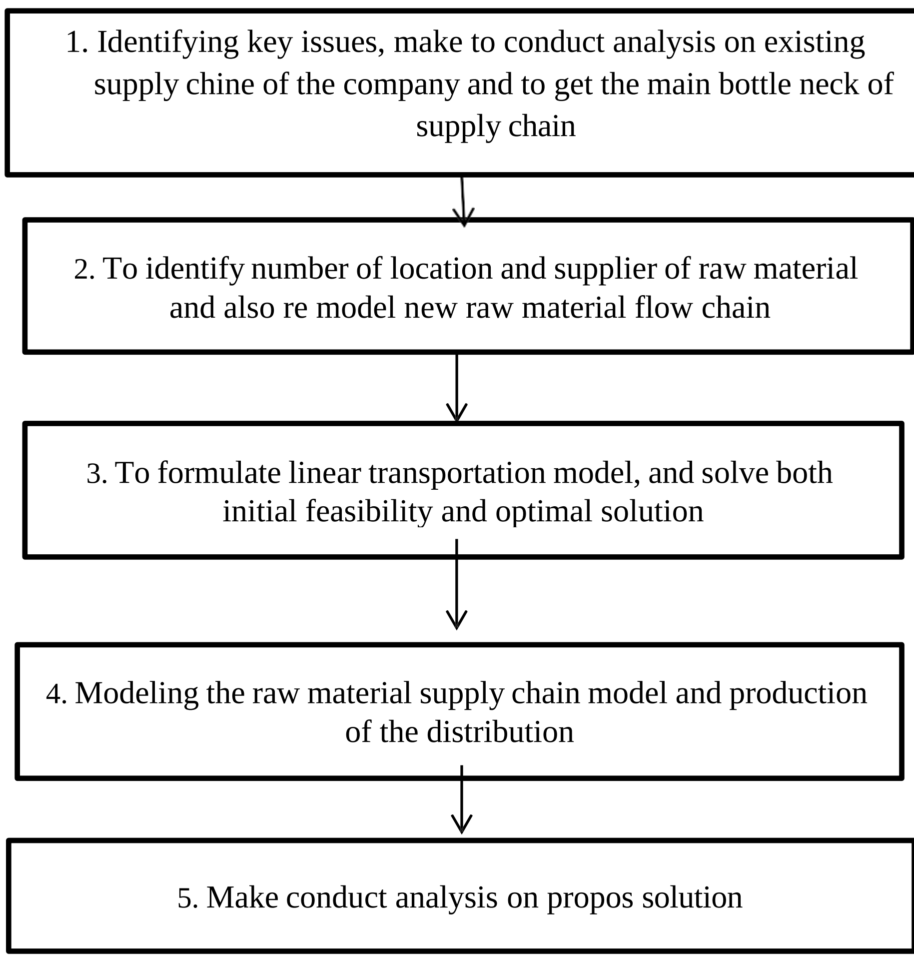

Figure 3.1. Research process flowchart

3.2. Research Design

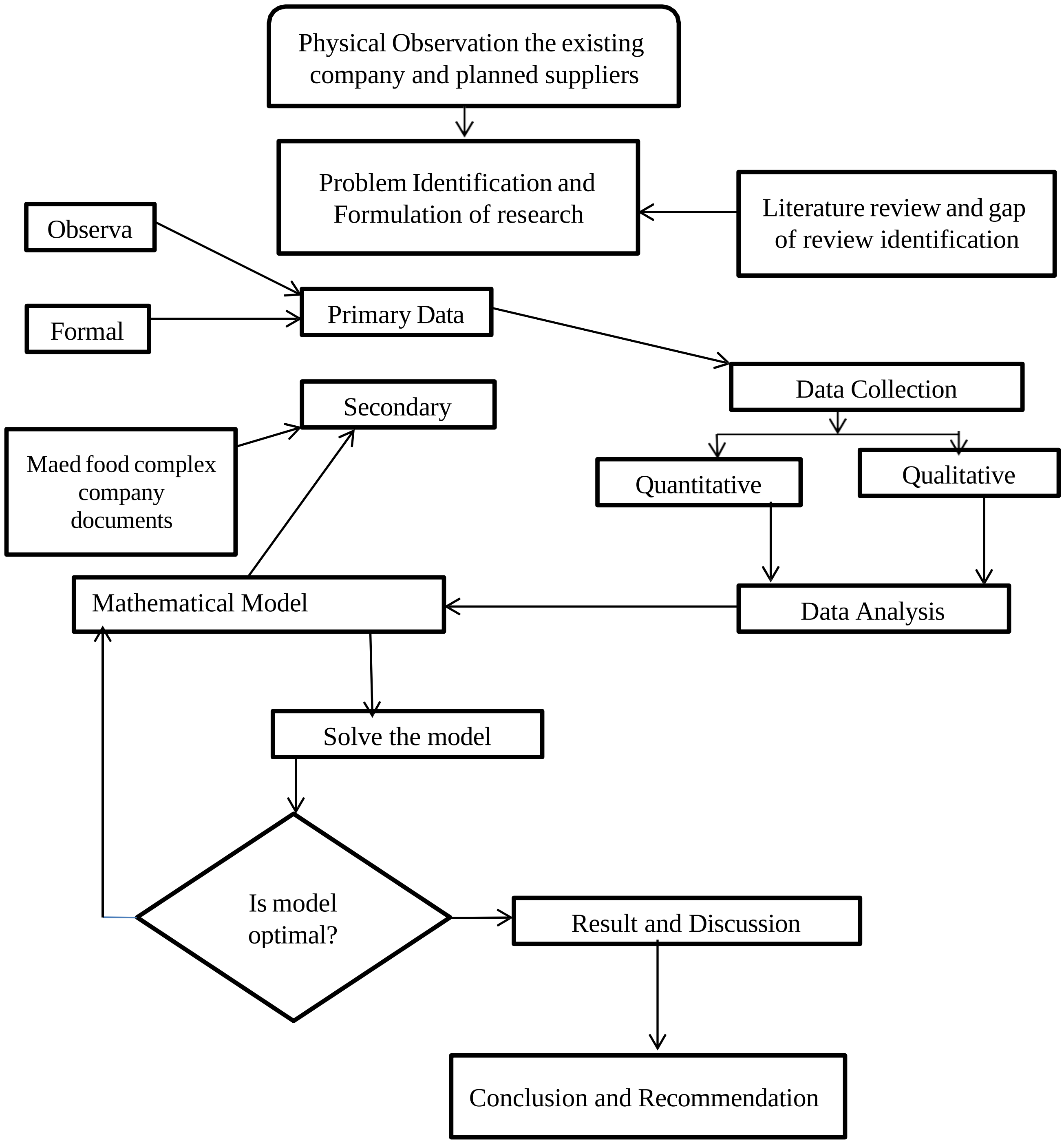

Figure 3.2 research flow diagram designs

3.3. Research Method

This study uses a qualitative and quantitative approach by identifying the best locations and determining the optimal supply chain strategy to minimize cost and satisfy customers. Relevant primary and secondary data are collected to address the stated objectives of the food company. Secondary data was collected from planned production capacity reports and research previously done to start the business. Direct observation on site visit is deployed to enable the investigator to keep track of the existing suppliers, the distance between the supplier and the company, the centers of the distributor, and to search areas that produce wheat for computing as a supplier. The other method of incurring data is through interviews with a formal questionnaire. To do this task, a random sampling technique is used for determining qualitative and quantitative data that is used for designing an optimal supply chain for the company.

CHAPTER FOUR

4. Data Collection and Analysis

4.1.1. Data Collection

Relevant data and current information are needed for better and perfect work since the thesis is highly dependent on the actual data of suppliers and transportation distance from the case company, and it is believed that the author supported well. The researcher uses some techniques for gathering and acquiring information from the case company. From this perspective, primary as well as secondary data collection methods for data collection should be deployed.

4.1.2. Primary Source of Data

Observation: - on the overall sites of supplier and retailer, Observations take place in the field where the phenomenon of interest exists. To conduct good information about the production system and volume of wheat at each site, the transportation system from farmers to the location of storage and from storage location to manufacturing company, to identify the number of locations and destinations the researcher done detail observation. Random sampling technique is used for selecting the day that the researcher executes observation and the personals that the researcher interview with personal questionnaire. Purposive sampling technique is used to interview company managers about the plan and capacity of the manufacturing firm.

Interviewing: - personnel’s with formal questionnaires .Interviews are a typical way for gathering qualitative data, and they are sometimes the only method employed. The usefulness of interviews lies in their ability to create rich data, the ease with which they may provide insight into the respondents' perceptions and values, and the simplicity with which they can be used to generate data for various studies. Due to this reason interview with formal questionnaire is use in this study.

Questionnaire: - data in order to increase the accuracy and effectiveness of the qualitative analysis. To analyze the research data and address problems the researcher employ multi criteria decision making method.

4.1.3. Secondary Source of Data

Literature review will be conducted regarding the concept of supply chain, design of supply chain, tools used to design supply chain and applications of supply chain design. These concepts obtained from books, international research journals, and internet websites.

Again this supports to understand, what other researchers did, the gap. Recorded document also used to have relevant data about locations of supplier and their distance to the company, maximum supply capacity, and the governmental issue around that site and other necessary information can be obtained by referring documents.

4.2. Data Analysis and Presentation

The researcher was used primary sources of data in order to collect relevant information. The closed ended questionnaires were designed based on the conceptual framework. Each question was analyzed from different aspects. It was clear, brief and understandable to the respondents as well as covers the relevant aspects of the model used after collecting all information needed for the research, the data analysis and synthesis carried out. And also, quantitative data related to transportation, distribution and inventory management model imputes will be collected to develop quantitative analysis about the other similar company's through survey, considering the recorded data's and company their daily monthly and annual reports. The secondary data gathered from the company feasibility study documents. Thus, important documents such as feasibility study documents and there quarter and annual production capacity plan , total capacity annual plan, company profile brochure, credit policy, and loan procedural manual, other relevant materials related to this study.

4.2.1. Tools and Techniques Used to Collect and Analysis Data

The information was gathered from both primary and secondary sources to assess the data. Therefore to facilitate such data some techniques and tools are needed.

4.2.2. Techniques

According to (Yu, 2012) Multi-criteria Cost, service standards, and on-time delivery are all criteria that supply chain management may incorporate into a performance measuring system. The other technique is Photography to catch up on the image and events on the villages of the supplier.

4.2.3. Analysis Method

For network design and transportation problem proposed mathematical modeling considering a range of factors addressing the SCN design and planning problem. From mathematical modeling approach for the design and planning of a food SCN, a mixed integer linear programming model is designed, taking into account environmental concerns and demand unpredictability (Souza Marques Gomes, 2016). Since, single criterion is frequently insufficient to evaluate a group of accessible choices. Multi- criteria decision making (MCDM) is a branch of operational research in which decision alternatives are evaluated against a set of many criteria and tests that MCDM is powerful method for solving problems with multiple constraints Ishizaka & Siraj, (2018) & Yu, (2012).

4.3. Criteria to Select Location

Most scholars and business experts agree that on the selection of business foundry area they consider geography proximity, government support, market potential, raw material capacity, labor force, technology availability or development, work culture of the community and network line between the supplier and customer integration.

Table 4.1. Criteria selected for selection of location of ware house

No	Criteria	Sub - criteria
1	Geography proximity	Proximityabout development line infrastructure, adaptable to human
2	Sectorial concentration	The executive jigged nearest special point about the place
3	Market potential	The production output easy to deliver into customer
4	Support service	Sister to one deficiencyon the other product type
5	Resource potential	Resource concentration scape up one project benefit
6	Labor requirement	The amount of worker always comparable to work strength
7	Technology	The place comfortable to develop technological input
8	Work culture	The working time and working tool are easy to use and to buy icheep
9	Network line deliver usproduct.	The place are on the line of networked and every technology in easy to transport

CHAPTER FIVE

5. Result and Discussion

5.1. Case Company Description

Mead food complex company is new installed company which needs some feasibility study. The main products of the company are wheat flour, pasta and biscuits processing factory. The company wants to uses the three major types of wheat such as, hard wheat, soft wheat, and durum wheat over 30,000 varieties of wheat.

5.1.2. Description of products

Pasta: is a ground grain of the wheat plant (genus *Triticum;* family *Gramineae* or grass), native to Eurasia, forms the fundamental component of commercial "pasta," the generic term for what the U.S. Federal Standards of Identity call "macaroni products." Italian commercial dried pasta combines durum wheat (*Triticum durum*, hard wheat, or semolina, it's coarsely ground endosperm) and water into a large number of shapes and sizes. Soft or common wheat (*Triticum vulgare*) is used for homemade or "fresh" pasta (which often contains egg, and sometimes oil and salt), as well as for bread and pastries. Some types of pasta are sown below on the diagram.

A. Strand Pasta B. Ribbon Pasta C. Tubular Pasta

D. Stuffed Pasta E. Shaped Pasta

Figure 5.1 Types of pasta products' in their shape

Macaroni is a variety of moderately extended, dry pasta made with durum wheat. Macaroni noodles normally do not contain eggs, (although they may be an optional ingredient) and are normally cut in Short, hollow shapes; however, the term refers not to the shape of the pasta, but to the kind of dough from which the noodle is made. Although home machines exist that can make macaroni shapes, macaroni is usually made commercially by large-scale extrusion. The curved shape is caused by the different speeds on either side of the pasta tube as it comes out of the machine.

5.1.3. Pasta Production Process

Having considered the different types of pasta, all the types follow similar production process flow. The main processes are explained as follows:

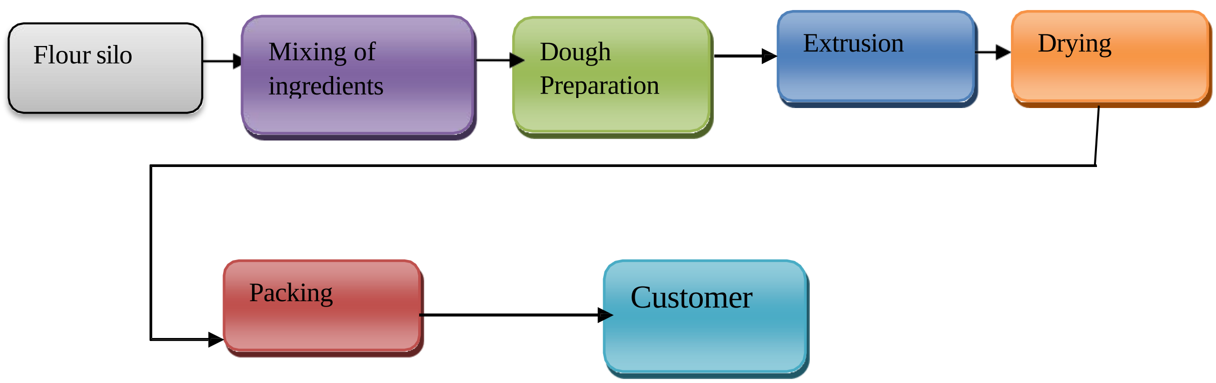

Figure 5.2: Process flow diagram of pasta production

5.1.4. Production Process of Biscuit Product

The process of biscuit manufacturing is conventional and easy. It mainly consists of four major processes mixing, forming, baking, cooling and packing. Wheat flour along with other ingredients is mixed with water and dough is prepared. Then it is kept at a normal room temperature for about couple of hours to allow proper fermentation. Then it is placed in biscuit molding trays and these trays are placed in oven for baking. After requisite baking, trays are taken out, cooled and biscuitsare packed.

5.1.5. Production program of the company

Production will commence at 70% of its capacity during the first year and 100% in the third year and onwards. The plant will require wheat (raw) 250 tons per day and 75,000 tons per annum at its full capacity. The plant produce wheat flour (net) 195 tons per day and 58,500 tons per annum at its full capacity. In addition, the plant produces pasta and macaroni 30,600 tons of which pasta 19,800 tons and macaroni 10,800 tons. And the envisaged plant produces 9,000 tons of biscuits of which Glucose

Biscuit, cream Biscuit and Cookies biscuit 4,500, 3,600 and 900 tons respectively. The proposed production program is shown in below the Table.

Table 5.1. Production Program for installed company

S/ No	Description	Unit of Measures	Year 1	Year 2	Year 3	Year 4
1	Wheat	tons	52,500	67,500	75,000	75,000
1.1	Bran (18%)	tons	945	12,150	13,500	13,500
1.2	Impurity (4%)	tons	2,100	2,700	3,000	3,000
1.3	Total deductable(22%)	tons	11,550	14,850	16,500	16,500
2	Net Flour	tons	40,950	52,650	58,500	58,500
3	Pasta and Macaroni	tons	21,420	27,540	30,600	30,600
3.1	Pasta	tons	13860	17820	19800	19800
3.1.1	Spaghetti Pasta- 500 gram	tons	12474	16038	17820	17820
3.1.2	Tagliatelle Pasta- 500 gram	tons	1386	1782	1980	1980
3.2	Macaroni	tons	7,560	9,720	10,800	10,800
3.2.1	Packed	tons	3780	4860	5400	5400
3.2.1.1	Macaroni- 500 gram	tons	3024	3888	4320	4320
3.2.1.2	Rotini (spiral macaroni)- 500 gram	tons	756	972	1080	1080
3.2.2	Un packed	tons	3780	4860	5400	5400
3.2.2.1	Macaroni (unpacked) - 50 kilogram	tons	3780	4860	5400	5400
4	Biscuit		6300	8100	9000	9000
4.1	Biscuit Production	tons	6,300	8,100	9,000	9000
4.1.1	Glucose Biscuit- 75 gram	tons	3,150	4,050	4500	4500
4.1.2	Cream Biscuits -75 gram	tons	2,520	3,240	3600	3600
4.1.3	Cookies biscuits-500 gram	tons	630	810	900	900

Diagrammatically the production program of mead food complex company is shown on figure below.

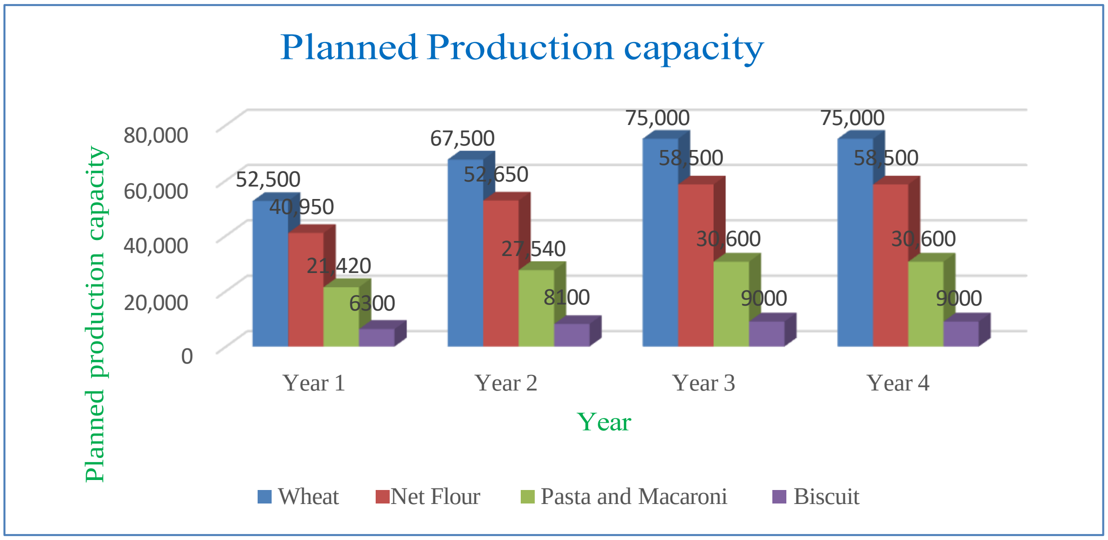

Figure 5.3. Planned production program of mead food complex company

5.2. Selection of Raw Material Suppliers

From the quantitative data gathered there are different suppliers that can supply their finished product (wheat) to mead complex company. To select such suppliers the company considers the capacity of their material supply and transportation cost.

According to CSA, Agricultural sample survey (2016/17) Wheat is estimated to be produced 42,192,572 quintal of which Oromia region estimated to produce 24,593,751 quintal and Amhara region 12,219,043 quintal.

Table 5.2.National wheat production (year 2016/17) in Quintal

No	Region	Production in Quintal	Share in %
1	Tigray	1,760,966	4.17
2	Afar	*	*
3	Amhara	12,219,043	28.96
4	Oromia Region	24,593,751	58.29
5	Somali Region	203,611	0.48
6	Benshangul Gumuz	67,402	0.160
7	S.N.N.P. Region	3,346,339	7.93
8	Gambela Region	280	0.00
9	Harari	1,180	0.00
	Total	42,192,572.00	100.0

5.3. Amhara Region wheat production Capacity

To select the best optimal supplier the researcher considers only suppliers in Amhara regional state considering the capacity and transportation cost with other regions. So, Wheat production in Amhara Regional state in EFY 20016/17 production year was 1,221,904.3 tons of which 313,856.10, 197,137.50, 220,647.90, 4,417.70, 149,393.30, 141,448.50and 51,568.40 tons produced in East Gojjam, North Shewa, South Wello, West Gojjam, South Gondar, North Gondar, and others respectively.

Table 5.3: Amhara Region 2008/09 Production year wheat production by zone

S. N	zone	Wheat production	
		Production (Quintal)	Percentage Share
1	N/Gondar	1,414,485.00	12.59
2	S/Gondar	1,493,933.00	13.29
3	S/wollo	2,206,479.00	19.63
4	N/wollo	474,444.00	4.22
5	N/Shewa	1,971,375.00	17.54
6	E/gojjam	3,138,561.00	27.92
7	W/gojjam	44,177.00	0.39
8	wag	79,790.00	0.71
9	awi	413,834.00	3.68
10	Argobba	2,206.00	0.02
11	Amhara	11,239,284.00	100.00

From the above table east Gojjam zone is high production capacity than others.

The researcherprioritizes such suppliers using Pareto chart as follows.

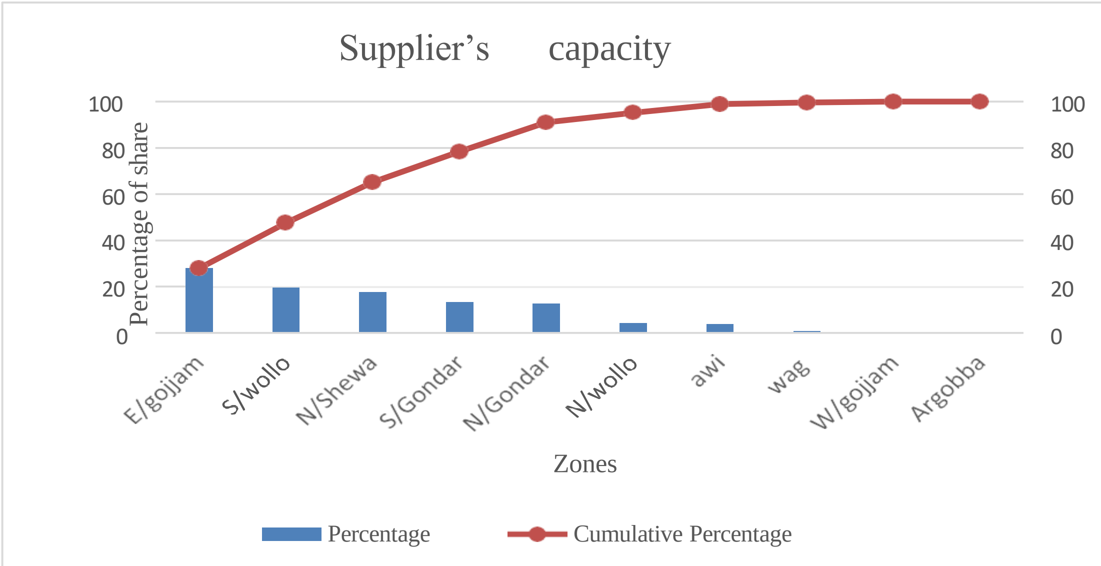

Figure 5.4. Pareto analysis for supplier capacity share

From the above diagram or Using 20/80 rule of Pareto four suppliers are selected based on their capacity share in Amhara regional zones. These are East Gojjam, South Wello, North Shewa and South Gondar. Based on the above recorded data Recorded transportation cost and quantity are shown below the table.

Table 5.4. Raw material supply to the company

No	Supplier	Total capacity Supply /year	Total capacity Supply /month
1	East Gojjam	3,138,561.00	261,546.75
2	South Wello	2,206,479.00	183,873.25
3	North Shewa	1,971,375.00	164,281.25
4	South Gondar	1,493,933.00	124,494.4167

The cost of transporting one ton of wheat from each supplier (source) to each destination differs according to the distance and vehicle system. These costs are shown below in the following table

.

Table 5.5: Transportation of unit cost of wheat transportation

Supplier	Debre Elias	Debre Birhan	Bahir Dar
East Gojjam	171/ton	525 birr/ton	470birr/ton
South Wello	560 birr/ton	510birr/ton	495 birr/ton
North Shewa	1200birr/ton	280birr/ton	650 birr
South Gondar	1700birr/ton	1890birr/ton	660birr/ton

- ✓ 117*c11+525*c12+470*c13(cost of wheat production transport shipping from East Gojjam birr/ton)
- ✓ 560 *c21+510*c12+495*c23 (cost of wheat production transport shipping from source south Wollo birr/ton)
- ✓ 1200 *c31+280*c32+650*c33 (cost of wheat production transport shipping from source north Shewa birr/ton).
- ✓ 1700 *c41+1890*c42+660*c23 (cost of wheat production transport shipping from source south Gondar birr/ton).

5.4. Matmatical model of transportation model

The total cost function is the minimum value of sum of fixed plants and warehouses costs, and transportation cost in supply of raw material and distribution of finished goods (transportation model). This model can simultaneously locate multi plant and warehouses for a company.

Basically, the initial basic feasible solution (IBFS) of a transportation problem cannot be considered as the optimal solution, because there may exist more better solution (which is called Basic Feasible Solution FBS) that optimize the objective function more better, and in order to evaluate whether a solution is the Basic Feasible Solution (BFS) for a particular problem, we use the optimality test to evaluate and improve the solution if there is need for improvement.

The problem is to determine how many tons of wheat to transport from a source to the distinction manufacture of company on a monthly basis in order to minimize the total cost of transportation.

The transportation of linear programming model for this problem formulated in the equations that follow below:-

- ✓ m=number of supply point
- ✓ n=number of demand points
- ✓ xij=number of units of supplied from supply points i to demand points j
- ✓ cjj= cost of shipping 1 units from supply point i to demand point
- ✓ si=supply at supply point i
- ✓ dj=demand at demand point j
- ✓ cij=coefficient of xij in row 0 of given table au
- ✓ aij=column for xij in transportation constraints

A transportation problem is balanced if total supply equals total demand. To use the methods of this chapter to solve a transportation problem, the problem must first be balanced by use of a dummy supply or a dummy demand point. A balanced transportation problem may be written as follows:-

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

s.t $\sum_{j=n} x_{ij} = s_i$ (i = 1,2, , , , , , m)

5.5. Unbalanced transportation model

Table 5.6. Unbalanced transportation model

From / To	Warehouse at Debre Elias	Warehouse at Debre Birhan	Warehouse at Bahir Dar	Supply
East Gojjam	C11 117	C12 525	C13 470	261,546.75
South Wello	C21 510	C22 560	C23 495	153,873.25
North Shewa	C31 120	C32 280	C33 650	114,281.25
South Gondar	C41 1700	C42 1890	C43 660	120,494.4167
Demand	244,731.8889	244,731.8889	244,731.8889	734,195.6667/734,195.6667

Total demand =734,195.6667 and total supply =650,195.6667, so total demand and supply are not equal, this called unbalanced problem.

5.6. Balancing transportation model if the supplier of raw material less than demand of company,

If total demand exceeds total supplier can be balance a transportation problem by creating a dummy supply point that has a supply equal to the amount of excess demand. Because shipments to the dummy point are not real shipments, they are assigned a cost of zero. Shipments to the dummy supply point indicate unused demand capacity.

Table 5.7 Unbalanced transportation model raw material less than demand

From / To	Warehouse at Debre Elias	Warehouse at Debre Birhan	Warehouse at Bahir Dar	Supply
East Gojjam	C11 117	C12 525	C13 470	261,546.75
South Wello	C21 510	C22 560	C23 495	153,873.25
North Shewa	C31 1200	C32 280	C33 650	114,281.25
South Gondar	C41 1890	C42 1700	C43 660	120,494.4167
	0	0	0	84,000(dummy supply point
Demand	244,731.8889	244,731.8889	244,731.8889	734,195.6667/734,195.6667

Now that the problem has been updated to a balanced transportation problem, it can be solved using any one of the following methods to solve a balanced transportation problem

- Northwest Corner Method
- Least Cost Cell Method
- Vogel's Approximation Method

5.7. Matmatical model for updated transportation model

- Objective function

The main objective of this transportation method is to minimize the transportation cost from each supply to each storage branch (destination).

- Decision variable

C11 is the amount of raw material (ton) from supply east Gojjam, with Warehouse at Debre Berhan

C12 is the amount of raw material (ton) from supply east Gojjam, with Warehouse at Debre Berhan

C13 is the amount of raw material (ton) from supply east Gojjam, with Warehouse at Bahir Dar

C21 is the amount of raw material (ton) from supply South Woll, with Warehouse at Debre Elias

C22 is the amount of raw material (ton) from supply South Wollo, with Warehouse at Debre Berhan

C23 is the amount of raw material (ton) the number of raw materials from supply south

C31 is the amount of raw material (ton) from supply North Shewa, with Warehouse at Debre Berhan

C32 is the amount of raw material (ton) the number of raw material from supply North South,

C33 is the amount of raw material (ton) from supply North Shewa, with Warehouse at Bahir Dar

C41 is the amount of raw material (ton) from supply South Gondar, with Warehouse at Debre Berhan

C42 is the amount of raw material (ton) from supply South Gondar, with Warehouse at Debre Eliias

C43 is the amount of raw material (ton) from supply South Gondar, with Warehouse at Bahir Dar.

- So the object function is:-

Minimize

z=117*c11+5251*c12+470*c13+560*c21+510*c22+495*c23+1200*c31+280*c32+650*c33+1700*c41+1890*c42+660*c43+0*c52+0*c53

- Subjected to:Supply constraints

117*c11+525*c12+470*c13=261,546.75

560*c21+510*c22+495*c23=153,873.25

1200*c31+280*c32+650&c33=114,281.25

1700*c41 +1890*c42 +660*c43=120,494.4167

0*c51 +0*c52 +0*c53=84,000 dummy supply

- Demand constraints

117*c11+560*c21+1200*+c31+1700*c41=244,731.888

525*c12+510*c22+280*c32+1890*c42=244,731.8889

470*c11+495*c21+650*c31+660*c41=244,731.8889

None negative constraint

c11,c12,c13,c21,c22,c23,c31,c32,c33,c41,c42,andc43,c51,c52,c53>

0*c51+0*c52+0*c53=84,000 dummy supply

5.8. Initial feasibility solution

5.8.1. Optimality Test for North West corner method

Table 5.8. North West corner method

From / To	C21 560	C22 510	C23 495	153,873.25
East Gojjam	C31 1200	C32 280 74,043.7778	C33 650 40,237.4722	114,281.25
South Gondar	C41 1700	C42 1890	C43 660	120,494.4167
	0	0	0	84,000
Demand	244,731.8889	244,731.8889	244,731.8889	

c11=244,731.8, c12=16,814.85, c22=153,873.25, c32=74043.7778,c33=40,237.4722and X43=120494.4167

Calculating the overall cost of transportation cost substituting this cell value is given by:-

$$\text{Minimize } z = 171 * c11 + 525 * c12 + 470 * c13 + 560 * c21 + 510 * c22 + 495 * c23 + 1200 * c31 + 280 * c32 + 650 * c33 + 1700 * c41 + 1890 * c42 + 660 * c43$$

$$= 171 * 244{,}731.8 + 525 * 16{,}814.85 + 470 * 0 + 560 * 0 + 510 * 153{,}873.25 + 495 * 0 + 1200 * 0 + 280 * 74{,}043.7778 + 650 * 40{,}237.4722 + 1700 * 0 + 1890 * 0 + 660 * 120{,}494.4167$$

Minimize z=255,565,221.286 Birr

5.8.2. Optimality Test for Minimum cost method

Table 5.9 Minimum cost method

From / To	Warehouse at Debre Elias	Warehouse at Debre Birhan	Warehouse at Bahir Dar	Supply
East Gojjam	C11 117 244,731.8	C12 525	C13 470	261,546.75
SouthWello	C21 560	C22 510	C23 495 183,875.3	83,873.25
North Shewa	C31 1200	C32 280 164,281.2	C33 650	164,281.25
South Gondar	41 1700	C42 1890 8,0450.6389	C43 660 44,041.73	24,494.4167
Demand	244,731.8889	244,731.8889	244,731.8889	734195.67/734195.67

5.8.3. Optimality Test for Transportation Problem: (Vogel's Approximation Method)

Table 5.10 Vogel's Approximation Method

Warehouse at Debre Elias	Warehouse at Debre Birhan	Warehouse at Bahir Dar	Supply				
C11 117 244,731.8	C12 525	C13 470 16,814.8611	261,546.75	353	353	353	353
C21 560	C22 510 46,450.6389	C23 495 107,422.6111	153,873.25	15	15	15	15
C31 1200	C32 280 114,281.25	C33 650	114,281.25	370	370	370	
C41 1700	C42 1890	C43 660 120,494.4167	120,494.4167	1040			
0	0,84000	0	84,000	0			
244,731.8889	244,731.8889	244,731.8889					
443	230	25					
443	230	25					
	230	25					
	15/15	155					

c11=244,731.8, c13=16,814.85, c22=46,450.6389, c23=107,422.6111, c32=114,281.25, and c43=120,494.4167

Calculating the overall cost of transportation cost by substituting this cell value is given by:

Minimize z=171*c11+525*c12+470*c13+560*c21+510*c22+495*c23+1200*c31+280*c32+650*c33+1700*c41+1890*c42+660*43

Minimize z= 171 ∗ 244,731.8 + 525 ∗ 0 + 470∗ 16,814.85 +560 ∗ 0+510 ∗ 46,450.6389 +495 ∗107,422.6111 + 1200 ∗0 +280 ∗114,281.25 + 650 ∗0 + 1700 ∗0 + 1890∗0 + 660∗120,494.4167

Minimize z = 238,141,200.6555

Supply constraints:-

$\sum i{=}m\ x_{ij} = d_j$ (j = 1,2, , , , , , n) Demand constraints

$X_{ij} >= 0$ (i = 1,2, , , , , , , , , , , , m; j = 1,2, , , , , n)

5.9. Optimal Solution

5.9.1. MODI Method – UV Method and loop method

There are two phases to solve the transportation problem. In the first phase, the initial basic feasible solution has to be found and the second phase involves optimization of the initial basic feasible solution that was obtained in the first phase. There are three methods for finding an initial basic feasible solution; I get the least cot from vogles method, then to use other more optimality method.

For U-V method the values ui and vj have to be found for the rows and the columns respectively. As there are three rows so three ui values have to be found i.e. u1 for the first row, u2 for the secondrow and u3 for the third row.

There is a separate formula to find ui and vj, ui + vj = Cij where Cij is the cost value only for the allocated cell.

Before applying the above formula we need to check whether m + n – 1 is equal to the total number of allocated cells or not where m is the total number of rows and n is the total number of columns.

In this case m = 4, n = 3 and total number of allocated cells is 6 so m + n – 1 = 6. The case when m +n – 1 is not equal to the total number of allocated cells will be discussed in the later post

Table 5.11 UV Method and loop method

		V1=117	V2=485	V3=470	
	From / To	Warehouse at Debre Elias	Warehouse at Debre Birhan	Warehouse at Bahir Dar	Supply
U1=0	East Gojjam	C11 117 244,731.8889	C12 525	C13 470 16,814.8611	261,546.75
U2=25	South Wello	C21 560	C22 510 46,450.6389	C23 495 107,422.6111	153,873.25
U3= -2 05	North Shewa	C31 1200	C32 280 114,281.25	C33 650	114,281.25
U4= 190	South Gondar	C41 1700	C42 1890	C43 660 120,494.4167	120,494.4167
U5=-485			0,84000	0	84,000

Vj, Uj +Vj=cij where cij is the cost value only for the allocated cell

Let U1=0;

U1+V1=117,0+V=117, then V1 =117,

U1+V3=470,0+V=470, then V3=470

U2+V3=U2+470=495, then U2=25

U2+V2=510.25+V2=510, then V2=485,

U3+V2=280, U3+485=280, Then U3= -205

U4+V3=660, U4+470=117, then U4=190,

U5+V2=0.U5+485=0, then U5=-485

Now, compute penalties using the formula $Pij = ui + vj – Cij$ only for unallocated cells.

For c12,(0+484)-525=-40

For c21, U2+V1-C21= (25+117)-560=-418

ForC31, U3+V1-C31= (-205+117)-560=-648

ForC33, U3+V3-C33= (-205+470)-650=385

ForC41, U4+V1-C41= (190+117)-1700=-1393

ForC42, U4+V2-C42= (190+485)-1890=-1215

All the penalty values are negative values. So the optimality is reached so no more reduction cost, it is reached at optimal. From the above table all transported quantity and amount to be transported is developed using stepping stone method of optimization. So, the transportation cost of this solution is computed by substituting the cell allocations (the amounts transported).

The minimum transportation cost for raw material is 238,141,200.6555 birr birr. So the optimal suppliers for each destination are for Debre Elias suppliers of East Gojam and for Debre Birihan south wollo, east Gojam and North Shewa and for Bahir Dar destination suppliers should be from North Shewa and south Gondar are preferable with calculated quantity.

5.10. Modeling Distribution system

The company planned to distribute its products to all cities in Ethiopia Distribution system of any industry can be classified as central distribution or decentralized distribution system (Girmaw, 2018). The existing planned distribution system of the company from their feasibility study follows the central distribution system The existing planned distribution system of the company from their feasibility study follows central distribution system and shown below.

Table 5.12 Modeling Distribution system

Product center	To distribute	Km
Debre Markos	Bahir Dar	265
	Addis Abeba	290
	Awi Zone /Kosober/	141
	W/gojjam/Finote Selam/	83
	Gondar	425
	Woldia	619
	Dessie	470
	Mekelle	887
	Debre Birhan	329

5.10.1. Distribution system for planned channel from Debre Marekos to Bahir Dare interims of operational cost

Table 5.13 Distribution system from Debre Marekos to Bahir Dare

Working hrs.	time	number of vehicles	capacity	frequency	amount unload/day
morning	11:30-7:30am	car 1	200 quintals	1	200
after noon	8:30-1:30pm	car 2	200quintals	1	200

A. Operation costs

driver	5000birr/month*2		10,000birr/month
fuel cost	car 1	388birr*26days	10,088birr/month
	car 2	892birr*26days	23,192 birr/month
supporter	2,500birr/month*2		5000birr/month

B. Labor Cost

Labor cost			
25birr/quintal*200	car 1	5000birr*26days	130,000 birr/month
25birr/quintal*200	car 2	5,000birr*26days	130,000 birr/month

drivers commission			
5 birr/quintal*200	car 1	1,000birr*26days	26,000birr/month
5 birr/quintal*200	car 2	180birr*26days	26,000 birr/moth

C. Operational costs.

working hr.	daily production capacity wheat per day (24hrs)	cost of product/quintal	Average daily demand
8hrs/day	2500 quintals/day	3200 birr/quintal	
26days/month	65,000quintals/month		

5.10.2. Distribution system for planned channel from Bahir dare to Gonder interims of operational cost

Table 5.14 Distribution system from Bahir dare to Gonder

Working hrs.	time	number of vehicles	capacity	frequency	amount unload/day
morning	12:30-6:30am	car 1	150 quintals	1	150

A. Operation costs

driver	2500birr/month*3		7,500birr/month
fuel cost	car 1	2840birr*26days	76,680birr/month
supporter	1000birr/month*3		3,000birr/month

B. Labor Cost

labor cost			
15birr/quintal*150	car 1	2250birr*26days	58,500 birr/month

drivers commission			
5 birr/quintal*150	car 1	750birr*26days	19,500birr/month

5.10.3. Distribution system for planned channel from Bahir dare to Wolida interims of operational cost

Table 5.15 Distribution system from Bahir dare to Wolida

Workin ghrs.	time	number of vehicles	capacity	frequency	amount unload/day
morning	12:00-8:30am	car 1	150 quintals	1	150
evening	12:00-8:00pm	car 2	150 quintals	1	150

A. operation costs

driver	5500birr/month*3		16,500birr/month
fuel cost	car 1	6390 birr*26days	166,140birr/month
	car 2	6390birr*26days	166,140 birr/month
supporter	2,000birr/month*3		6,000birr/month

B. Labor Cost

labor cost			
20birr/quintal*150	car 1	3000birr*26days	78,000 birr/month
20birr/quintal*150	car 2	3,000birr*26days	78,000 birr/month

drivers commission			
5 birr/quintal*150	car 1	750birr*26days	19,500birr/month
5 birr/quintal*150	car 2	750birr*26days	19,500 birr/moth

5.10.4. Distribution system for planned channel from Wolida to Desia interims of operational cost

Table 5.16 Distribution system from Wolida to Desia

Working hrs.	time	number of vehicles	capacity	frequency	amount unload/day
morning	12:30-6:30am	car 1	150 quintals	1	150

A. Operation costs

driver	3000birr/month*3		9,000birr/month
fuel cost	car 1	2130irr*26days	55,380birr/month
supporter	1,000birr/month*3		3,000birr/month

B. Labor Cost

labor cost			
15birr/quintal*150	car 1	2250birr*26days	58,500 birr/month

drivers commission			
10birr/quintal*150	car 1	1,500birr*26days	39,000birr/month

5.10.5. Distribution system for planned channel from Wolida to Mekela interims of operational cost

Table 5.17 Distribution system from Wolida to Mekela

Working hrs.	time	number of vehicles	capacity	frequency	amount unload/day
morning	12:30-8:30am	car 1	150 quintals	1	150

A. Operation costs

driver	4000birr/month*3		12,000birr/month
fuel cost	car 1	3550irr*26days	92,300birr/month
supporter	1,500birr/month*3		4,500birr/month

B. Labor Cost

labor cost			
25birr/quintal*150	car 1	2250birr*26days	58,500 birr/month

drivers commission			
10birr/quintal*150	car 1	3,750birr*26days	97,500birr/month

5.11. Planned distribution system of the company

Supply chain distribution is the way in which businesses get their products to customers. Distribution plans largely depend on the financial and company goals of the business. The company may choose to sell products directly to their clients while others use third-parties for distribution purposes. In order to be successful, the company supply chain distribution should be formalized through an organized plan. Formal distribution plans reduce the cycle days between when a customer places an order to delivery. Supply Chain Management Review states that those who have an extensive distribution plan only take a few days for order fulfillment. In comparison, those without a distribution plan take above 10 days.

But the new planed Supply chain distribution system is used to balance supply and demand based on company's capacity. The company distribution plan should be able to handle any type of market changes, including supply disruptions and demand increase.

5.12. New Proposed Model of Network

Network development may involve the issues to plant, warehouse, transportation, and retailer location. This are strategic decisions have a long-lasting effect on the company. To come up with a better network design, appropriate numbers of warehouses, location of each warehouse, and the size and capacity of each warehouse have to identified and determined. According to (Christopher, 1999) SC, a complex network of organizations and facilities which are mostly settled in a vast geographical area or even the globe, synchronizes a series of interrelated activities through the network. The objective of this paper is to design new supply chain network in this case is to use the available resources efficiently and effectively, minimize the total costs, improve customer satisfaction, then to improve market share.

Increasing the number of distribution centers typically yields: improving in service level, increase in inventory costs, increase in overhead and set-up costs, and reduction in outbound transportation costs, and increase in inbound transportation costs.

This means opening distribution centers at all the proposed location. Thus, distribution locations are critical determinants for the efficiency of the product distribution.

According to Simchi-Levi et al. (2004) and Ghiani, Laporte, and Musmanno (2004),SC network is also referred to as the logistics network by defines the SC as "a complex logistics system in which raw materials are converted into finished products and then distributed to final users consumers or companies.

The objective is to design the SC network, so as to minimize annual system-wide costs and improve service level requirements, there after increase market share. Increasing the number of warehouses typically harvests: improvement in service level, increase in inventory costs, increase in overhead and set-up costs, and reduction in outbound transportation costs. And increase in inbound transportation costs. In this setting the tradeoffs are clear. In spirit the firm must balance the costs of opening new warehouses with the advantages of being close to the customer. Thus warehouse location decisions are critical determinants for the efficiency of the product distribution.

5.13. New Planned distribution system of the company

The existing planned distribution system of the company from their feasibility study follows the central distribution system. To select the distribution centers for products the location rating factor method is employed. because factor rating is a general approach to evaluating location that includes quantitative and qualitative inputs. Among the four methods for evaluating location alternatives, factor rating is the most widely used technique. The following points are the factors to consider for site selection for distribution centers (Ref: Accessibility to major linkages (major roads)

- ✓ Customer locations
- ✓ Transportation access and timing
- ✓ Competitor locations
- ✓ Government regulations
- ✓ Shipping modes
- ✓ Cheapest land
  - ➢ Location Rating Factor steps:-
- ✓ Identify important factors
- ✓ Weight factors (0.00 - 1.00)
- ✓ Subjectively score each factor (0 - 100)
- ✓ Sum weighted scores

Table 5.18. Selected factors with its weight and score

No	Location	Weight	Scores (0 to 1000)		
			Woldia	Dessis	Mekele
1	Accessibility to major roads	0.30	90	65	80
2	Customer location	0.20	75	91	100
3	Transportation access	0.15	72	95	60
4	Competitor location	0.15	80	80	75
5	Government	0.10	95	90	65
6	Shipping mode	0.05	65	92	85
7	Cheapest land	0.05	90	65	50

The formula to calculate weight score is as follows. Weighted score = weight * score

For example for "accessibility to major roads" to woldia = (0.3) * (90) = 27.

Based on this calculation the weight scores for all factors to the three cities are listed in Table Below:-

Table 5.19 weight scores for all factors

Weighted Scores		
Woldia	Dessie	Mekele
27.00	19.5	24.0
15.00	18.2	20.0
10.8	14.25	9.0
12.00	12.0	11.25
9.5	9.0	6.5
3.25	4.6	4.25
4.5	3.25	2.5
82.05	80.80	77.50

Based on the calculation the distribution center can be located at Woldia because it has the highest weighted score compared to Mekele and Dessie. By using this method (calculation) all distribution sites are selected. Figure 5.5 shows the selected sites for distribution center.

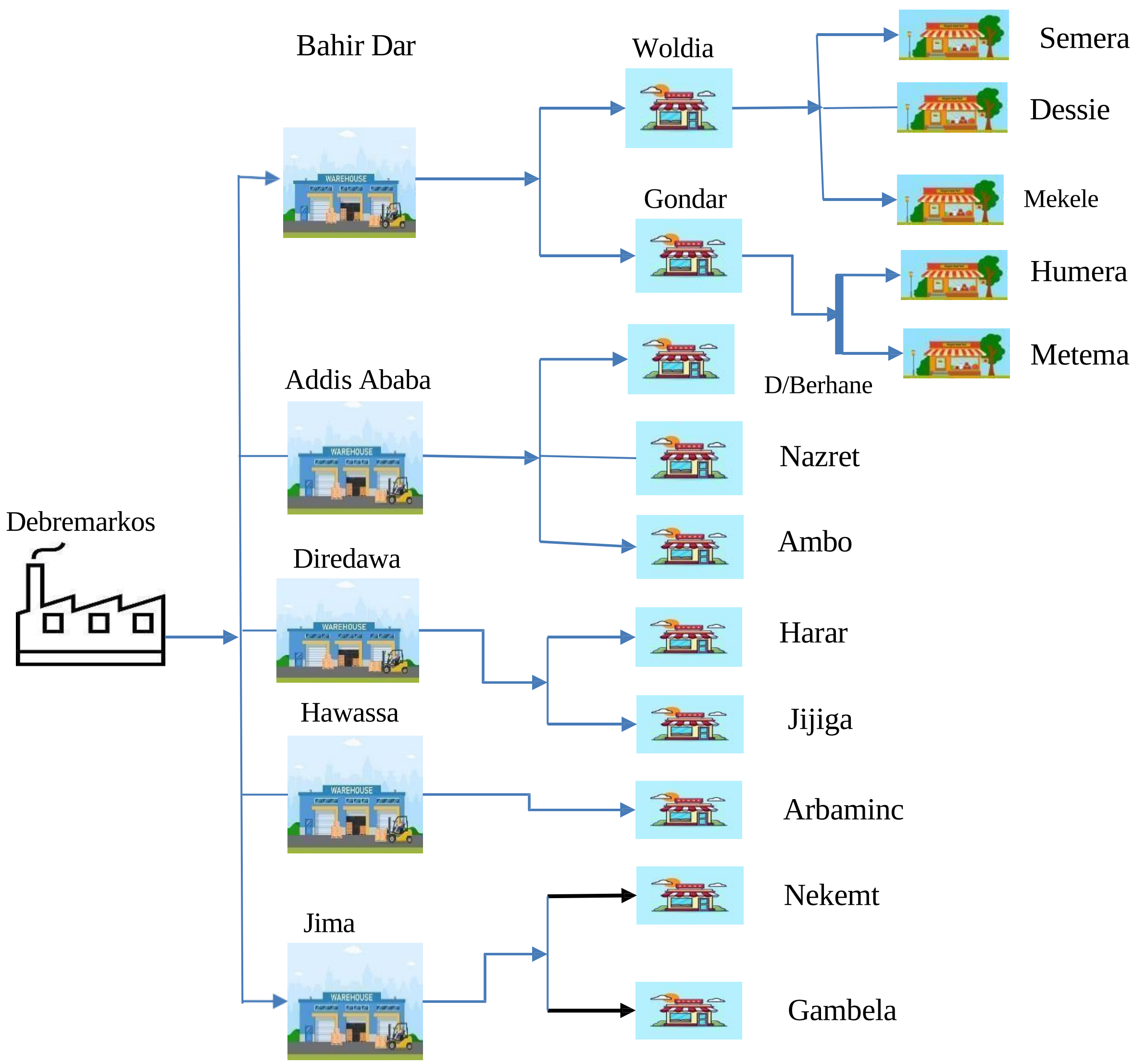

Figure 5.5 Product distribution network

For the above product distribution network shows that allows the company to distribute their products and deliver them to their new customers on time it is the shortest and controlled system. This means that when the company uses a new product distribution method, easily control the Transport Cost, the intermediary and other unnecessary costs.

5.14. New Supply chain network Design

Network development may involve the issues to plant, warehouse, transportation, and retailer location. This are strategic decisions have a long-lasting effect on the company. To come up with a better network design, appropriate numbers of warehouses, location of each warehouse, and the size and capacity of each warehouse have to identified and determined.

According to (Christopher, 1999) SC, a complex network of organizations and facilities which are mostly settled in a vast geographical area or even the globe, synchronizes a series of interrelated activities through the network.

The objective of this paper is to design new supply chain network in this case is to use the available resources efficiently and effectively, minimize the total costs, improve customer satisfaction, then to improve market share. Increasing the number of distribution centers typically yields: improving in service level, increase in inventory costs, increase in overhead and set-up costs, and reduction in outbound transportation costs, and increase in inbound transportation costs. This means opening distribution centers at all the proposed location. Thus, distribution locations are critical determinants for the efficiency of the product distribution.

According to Simchi-Levi et al. (2004) and Ghiani, Laporte, and Musmanno (2004) ,SC network is also referred to as the logistics network by defines the SC as "a complex logistics system in which raw materials are converted into finished products and then distributed to final users consumers or companies.

The objective is to design the SC network, so as to minimize annual system-wide costs and improve service level requirements, there after increase market share.

Increasing the number of warehouses typically harvests: improvement in service level, increase in inventory costs, increase in overhead and set-up costs, and reduction in outbound transportation costs. And increase in inbound transportation costs. In this setting the tradeoffs are clear. In spirit thefirm must balance the costs of opening new warehouses with the advantages of being close to the customer.

Thus warehouse location decisions are critical determinants for the efficiency of the product distribution.

According to (Chopra, 2006) and (Daniel Kitaw,2011) the design approaches therefore, requirethe three major activities to produce good optimized result.

The end goal is to create the most efficient network possible, meet the demand of customers, and ensure the lowest possible cost to serve your network.

This process includes many different variables and models but many of them are tied to locationsuch as:-

- ✓ Company distribution centers,
- ✓ Store network, and possible routes to serve those stores
- ✓ Other assumptions we using in this new supply chine

designs are,

- ➢ Number of transportation resources,
- ➢ Assumed delivery time, and total route time are also tied to location –
- ➢ Even though theymight not initially appear to be impacted by location.

5.15. New supply chain network design of the company

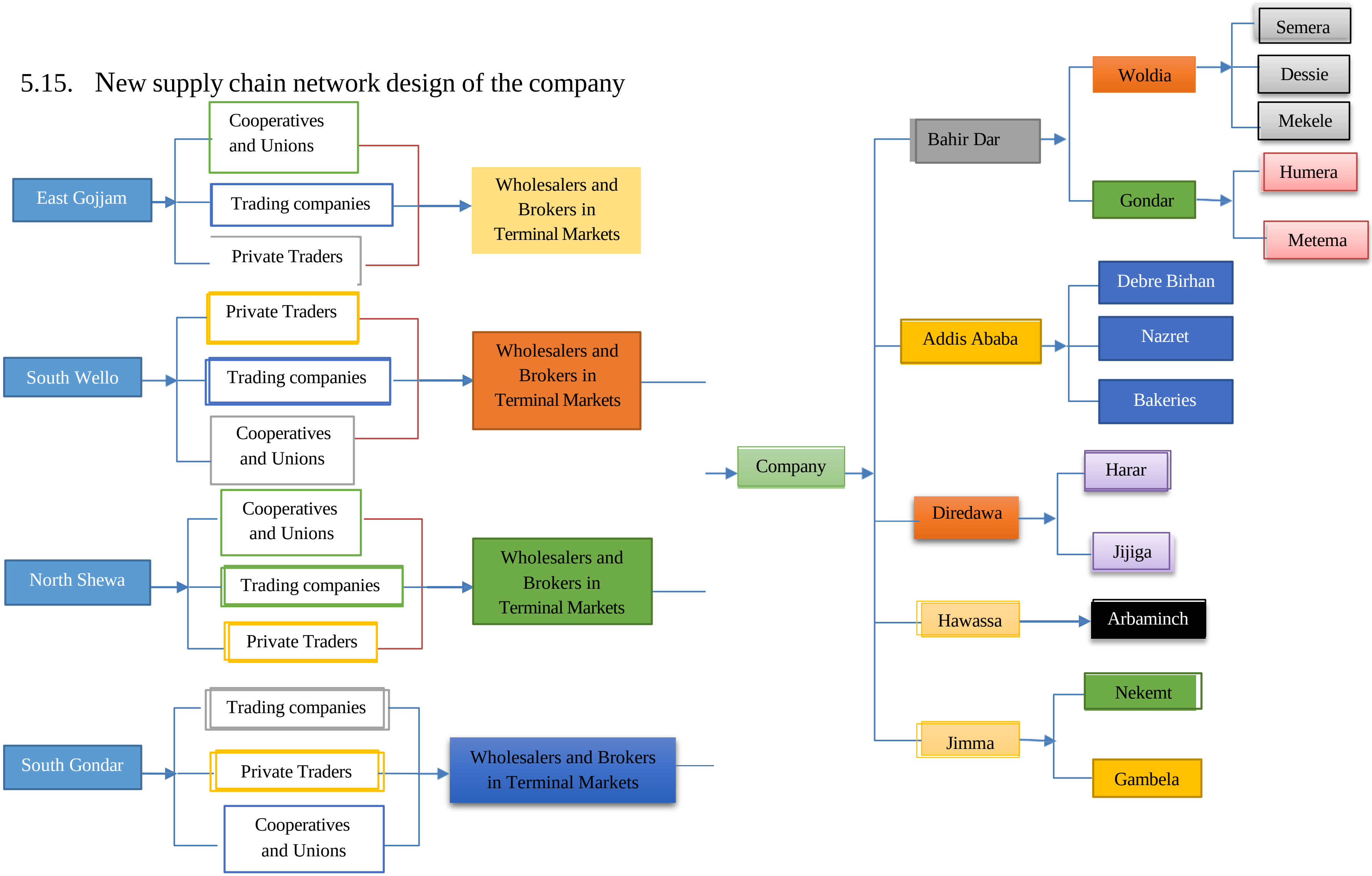

Figure 5.6. New supply chine design network

CHAPTER SIXE

6. Conclusion and Recommendation

6.1. Conclusion

This study conducts the new supply chain design for Mead food complex company. Food supply chain management is a complex process owing to the natural characteristics of supply chains and fast moving and highly competitive food sector. From the results of the analysis carried out the conclusion it is shown that all three methods of finding initial basic feasible solution (North-West corner method, Least Cost method and Vogel Approximation method) gave varying answers. (North-West corner method, Least Cost (minimum) method and Vogel Approximation method) gave varying answers. The North-West corner method gave transportation cost of 255,565,221.286 ETB, Least Cost (minimum) method gave transportation cost of 385,801,916.946 ETB and Vogel Approximation method gave 238,141,200.6555 ETB as its transportation cost. The above result shows that Vogel Approximation method is the most efficient of initial basic solution all the methods because it has the least transportation cost, from start this result to calculate more optimal solution by using An MODI Method

– UV Method gave 238,141,200.6555. From the optimization of the cost by MODI method-UV method. From the result and discussion part the facility location is selected at Dberemarkos usig different criteria.

The main suppliers for the company are east Gojam, south wello, North Shewa and south Gondar. Proposed destinations for raw material are Debre Elias, Debre Birihan and Bahir Dar. Having those destinations the transportation model result reveals 244,731.89 tone and 16,814.85 tone supply from east gojam to Debre elias and Debre Birhan respectively. South wello supply 46,450.6389 kg, and 107,422.6111 tons, raw material to Debre Birhan and ,Bahir Dar respectively. South Gondar supply 120,494.4167 tons raw material to Bahir Dar. The final supplier which is North Shewa supply 114,281.25 tone to Debre Birhan and 84,000 tone somewhere or may be store at company inventory by zero cost at the minimum cost of transportation of 238,141,200.6555 ETB.

The proposed supply chain design model is developed with a minimum cost and capacity of each supplier and company proposed distribution. In general, supply chain design is necessary and important for the performance of the company and customer satisfaction

6.1. Future works

In futures ,the research will conducts by using analytical nonlinear transportation real model make Decisions on production, Transportation and Inventory issues and provide A specific optimization algorithm as solution By taking chain behavior as stochastic element for multi-period and multi-mode of transportation, and also consider multi goal of supply chain such as, Reducing cost ,improving responsiveness, demand of uncertainties.

6.2. Recommendation

The following suggestions are made by the researcher in light of the data and conclusions presented: Based on the conclusion of the project research work, I recommend that the company implements the new model of design warehouse to find the shortest routes from their current raw material supplier to any delivery store of Choice now and in the nearest future to help them;

- ✓ Minimize the cost of transporting the raw materials,
- ✓ To farming raw materials of wheat production by organization on near Dbre Markos farm land.
- ✓ To expand other new food complex factory in different area, in Adis Abeba,Dbere Brihan and Dbre Tabore
- ✓ Based on the finding the researcher recommends the company to use designed supply chain network for facilitate the program and improve performance of the company.
- ✓ The company may need to review its supply chain management practices with a systematic management of the whole process of production lifecycle phases after installment through the collaboration among different actors and all stakeholders.
- ✓ Minimize the cost of running the transportation of goods to maximize profits of the company

The researcher advises utilizing this really beneficial study as a baseline for future researchers' studies to identify additional scientific assessment of the company supply chain design.

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7.1. APPENDIX

Demographic Data of selected candidate for interview using structural questionnaire:-

7.1.1. Dear Respondent,

Bahir Dar university master's thesis entitled "FOOD SUPPLY CHAIN DESIGN AND ANALYSIS USING MULTTI CRITERIA DECISION MAKING FORMULATED MODEL" with the objective to carry out an in-depth supply chain analysis to generate sufficient information on the main opportunities and bottlenecks for wheat products. This study is likely to contribute significantly to increase supplier. Production, distribution performance. 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 +251 912301002 thank you very much for your time and suggestions.

Appendix PART-1A:PLEASE TICK **(√)**

A: Demographic Data

1. Gender: (1) Female__________(ii) Male
2. Age (years): (i) 18 – 30___________(ii) 31 – 40______ (iii) 41 – 50_____ (iv) Over 50_____
3. Educational Background: (i) 10t ---------(ii) Diploma/TVET _______
   (iii) FirstDegree_________(iv) Master's Degree------
4. Marital Status: (i) Married_____(ii) Unmarried____(iii) Single____(iv) Divorced _____
5. YOU'RE WORKING DEPARTMENT (Team For Facility Location Decision Criteria)
   (i) Production Department___________(ii) Marketing Department_______
   (iii) Human Resources Department-------------
   (iv) Finance Department______(v) Maintenance Department_______
   (vi) Purchasing Department _____
   (viii) If other mention ....

7.2. Appendix 1B: The Factors that affect the facility location of the Firm

"Is the following factor affecting the Facility location of Mead food complex?" Please make tick onthe box based on your perception.-

No.	Factors	1	2	3	4	5
1	Proximityto market	Totally Disagree	Disagree	Neutral	Agree	Totally Agree
2	Proximityto raw materials	Totally Disagree	Disagree	Neutral	Agree	TotallyAgree
3	Access to infrastructure	Totally Disagree	Disagree	Neutral	Agree	Totally Agree
4	Availability ofskilled manpower	Totally Disagree	Disagree	Neutral	Agree	TotallyAgree
5	Market for by products	Totally Disagree	Disagree	Neutral	Agree	TotallyAgree
6	Work Culture	Totally Disagree	Disagree	Neutral	Agree	Totally Agree
7	Technology	Totally Disagree	Disagree	Neutral	Agree	TotallyAgree
8	Network line	Totally Disagree	Disagree	Neutral	Agree	TotallyAgree
	Other criterion	Totally Disagree	Disagree	Neutral	Agree	Totally Agree

7.3. Appendix 1C: weighted score of respondent for each decision criteria

In what range (Percentage) the criteria affect the site location of the firm?

		Percentage Value (%)				
No.	**Factors**	0-20	20-40	40-60	60-80	580-100
1	Proximityto market					
2	Proximityto raw materials					
3	Access to infrastructure					
4	Availability of skilled manpower					
5	Market for byproducts					
6	Work Culture					
7	Technology					
8	Network line					
9	Other criterion					

7.4. Appendix 1D: Questioner for Agricultural sector of Ethiopia

- Wheat production capacity of each regional state in Ethiopia

No	Region	Production in Quintal	Share in %
1	Tigray		
2	Afar		
3	Amhara		
4	Oromia Region		
5	Somali Region		
6	Benshangul Gumuz		
7	S.N.N.P. Region		
8	Gambela Region		
9	Harari		

- Production capacity of selected zones of Amhara region

S. N	**zone**	Wheat production
		Production (Quintal)
1	N/Gondar	
2	S/Gondar	
3	S/wollo	
4	N/wollo	
5	N/Shewa	
6	E/gojjam	
7	W/gojjam	
8	wag	
9	awi	
10	Argobba	