THE STUDY ON CRITICAL SUCCESS FACTORS AND PROBLEMS FOR MANAGING FOOD SUPPLY CHAINS

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CERTIFICATE OF DISSERTATION

This is to certify that this dissertation, entitled **"The Study on Critical Success Factors and Problems for Managing Food Supply Chain" being submitted by Mr. Sanjeev Yadav** in the fulfillment for the award of degree of "**MASTER OF TECHNOLOGY"** with specialization in "**PRODUCTION AND INDUSTRIAL ENGINEERING**" submitted to **DELHI TECHNOLOGICAL UNIVERSITY, DELHI** is a bona fide thesis work carried out by him under my supervision.

The matter in this dissertation has not been submitted to any other university or institute for the award of any degree.

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ABSTRACT

In the present age of globalization and industrialization, food organizations need to improve their performance for their high productivity and cost minimization. To meet this requirement all members of supply chain need to work properly and in an organized way. In the first part study has carried out to need of supply chain management in food supply chain, problems encounter in supply chain and various performance factors in food supply chain.

In the next part, critical success factors of food supply chain have been identified based on literature review. Then these critical success factors have been ranked with the help of techniques for order preference by similarity to ideal solution (TOPSIS).TOPSIS method has relatively high rationality and applicability when it is used to rank the critical success factors of food supply chain.

In next part, all identified critical success factors of food supply chain grouped into three parts assets, processes and performance. Study proposed a framework based on fuzzy AHP. This proposed framework provides more accurate data for selecting best food supply chain. By the help of fuzzy AHP, we have compare the three food supply chains and find out the best supply chain on the basis of three factors Assets, Processes and Performance.

Finally all findings from different section have been combined in the last chapter.

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CHAPTER 1

INTRODUCTION

1.1 Background

It is only during the last ten years that the agri food industry has recognized that SCM as a key concept for its competitiveness. The rapid industrialization of agricultural production, problems in the food distribution sector, the advancement of Information and Communication Technologies (ICT) in logistics, customer concerns for food safety and governmental food safety regulations, the establishment of specialized food quality requirements using various ISO standard, the emergence of modern food retailer forms, the importance of vertical integration and horizontal alliances, as well as the emergence of a multinational corporations in the last few decades are just a few of the real-world challenges that have led to the adoption of SCM in the agri food sector (Chen, 2006). In general, an AFSC is comprised of a set of activities in a "farm-to-fork" sequence including farming (i.e. land cultivation and production of crops), processing/production, testing,

Packaging, warehousing, transportation, distribution, and marketing (Iakovou, et al 2012). Finally, the utilization of precision agriculture technologies (i.e. satellite imagery and geospatial tools) has emerged lately as a means to promote farming efficiency and environmental

sustainability so that it fulfill the growing need of food demand (Busato et al ,2013).The agribusiness and food chains are transforming from a local markets towards a vertically coordinated organized food system. This leads to more competition between supply chains and networks rather than competition between individual firms .This trend lead to adapt old or develop new views on the functioning of the agribusiness and food markets. In recent years researchers have recognized the relevance of food supply chain management for the agri-food sector (Van der Vorst, 2000) due to complexity of products and the need for quality controlled flows of the products through customer and various quality standards. This means that original good quality products can easily deteriorate because of a careless action of one of the member in the chain. Supply chain management is defined as a network of interconnected and independent organizations mutually and cooperatively working together to control, manage and improve the flow of materials and information from farmer, supplier to end user (Christopher, 1998). Nowadays consumers put more focus and interest on issues such as product quality, food safety, product diversity and service (Van der Vorst, 2005). These demands have been raised due to several crises in agri-food sectors such as Bovine Spongiform Encephalopathy (BSE) and swine fever in 1997,the dioxin affair in 1999, fatal foot and mouth disease (FMD) in 2001, the disaster nitrophen and medroxyprogestron acetate (MPA) incidents in 2002, and the dioxin affair and Avian Influenza(common cold) in 2003. Besides, governmental regulations concerning environmental issues and food safety issues, the last decades are in hand of all disease. Therefore, agri food supply chains are becoming an interconnected system with a large variety of complex relationships and need to be managed properly. These relationships are reflected in the formation of food supply chain networks (via alliances, horizontal and vertical cooperation, forward and backward integration in the supply chain and continuous innovation). This implies the development and implementation of enhanced quality, logistics and information systems(cold storage, inventory management) that enables more efficient realization of processes and more frequent exchange of massive information for coordination purposes (Van der Vorst , 2005). In this era of globalization of markets many companies realized that, in order to evolve an efficient and effective supply chain, supply chain management needs to be assessed for its performance.

1.2 Need of food supply management

In general, for efficient and effective food SCM, an un obstructed flow of information to every person involved in supply chain is a prerequisite, but especially in cases such as producer–exporter relationships in the agri food sector (Jraisat *et al.*, 2013), the level of information sharing is even more important. It is used to help direct the allocation of resources, access and communicate progress towards strategic objectives and evaluate managerial performance .Besides, It helps managers to identify good performance, helps to make the balance between profit and investment, provides means to set strategic targets and ensures that managers are aware when to get involved if business performance is distracting (Neely et al., 1994).In the broadest sense the measurement and performance data are used to secure the control of the organization .Measuring the performance of agri food supply chains is even more difficult, because agri food supply chains are different from other supply chains in some aspects (e.g. perishability, long production throughput time, seasonality). Important distinctions are made between daily fresh products (vegetables and fruits), chilled products (salads, dairy products, etc.), frozen products (fish, ice, etc.) and non-perishables as sugar and coffee (Van der Vorst, 2000). Qualitative performance indicators mean that consumer acceptance of the product (qualitative aspects such as taste, texture) need to be taken into account along with other non-qualitative performance indicators.

1.3 Reliability of food supply chain

Food supply Reliability is an overall performance measure that depends on the performance of the different stages supply chain .The performance of a supply chain can be defined by supply chain profitability, which has only one source of income: the customer (Chopra and Meindl, 2001). According to Vander Vorst (2000) supply chain performance is the degree to which a supply chain fulfils end user requirements concerning the relevant performance indicators at any point in time regarding total supply chain cost. According to Neely et al. (2005) performance measurement is the process of quantifying the efficiency and effectiveness of all the action involved in supply chain. Lambert and Pohlen (2001) summarized the major issues in checking reliability of food supply chains as follows:

1. The lack of measures that analyze performance across the entire supply chain i.e. path tracker for food product, decoding of bar codes.

2. The requirement to go beyond internal firm measures and to go to food supply chain perspective i.e. farmer condition, relation between member.

3. The requirement to align activities and share joint performance measurement information to implement strategy that achieves supply chain objectives i.e. proper interlinking between quality department and manufacturing department.

1.4 Problems in analyzing food supply chain: Analyzing agri-food supply chains revealed several problems which are:

1. The importance of measuring performance in obtaining competitive advantage in the supply chain, relatively little research has been undertaken to provide a thorough understanding of measuring and improving performance in the food industry.

2. Many food firms do not monitor performance indicators in a systematic way and there is a mismatch what manufacturers measure (ISO STD, 9001)) and what their customers view as important (Collins et al.,2001). All these studies are base on the HACCP approach and its seven principles described in the Codex Alimentation (, Fotopoulos, .et. al 2011) with the introduction of the international standard ISO 22000 (International Organization for Standardization, 2005) this approach was slightly modified by strengthening the management elements and the proposed improvement security controls. The ISO 22000 relates to food safety as part of a comprehensive management system standard. This approach is similar to that followed by ISO 9001 - quality management systems, ISO 14001 - environmental management, ISO 18801 - safety management and occupational health. In this context, an organization may voluntarily decide to implement

ISO 22000 and then seek certification by an authorized certification body, and thus get verification by independent third parties of the effectiveness of its practices related to food safety. several quality certification systems have been introduced to AFSCs in order to enhance the ability of an organization to control food safety

hazards and to ensure the safety of the consumers (e.g. ISO 22000:2005, 2005)

3. A knowledge gap between farmers and processors about e.g. business practices, product supply, quality expectations. Therefore, farmers and processors poses different questions to improve supply chain performance, which leads them to the risk of miss-specifying each other's decision process.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

food industry has undergone significant change during last three decades but a few, big collective farms (Reardon ,2000) have ceased to exist or been reorganized; new small food producers have appeared. Food industry supply chains consist of many interrelated units which need to be interconnected and interrelated, namely food producers, food processors, wholesalers, warehousing facilities, retailing, transportation and customers. The agri-food industry is being exposed to an unpredictable level of change to its inside and outside environment (Collins & Dunne,2002) and must innovate in order to successfully adapt to a changing business environment and to sustain (Sparling et al, 2005). Green farming practices of agriculture have also been addressed in the literature as essential for successful AFSCs' sustainability (Cantrell et al., 2012). Consumer purchasing pricing inter-company transaction, they prove to a poor indicator of a product's true value and an ineffective basis from which to develop cooperation between companies and other food firm .

2.2 Definition and issues of food supply chain

Supply chain can be defined as "a system which have many interrelated system such as material suppliers, production facilities, distribution services and customers linked together via the feed forward flow of materials and the feedback flow of information" The key idea of the supply chain concept is that customer needs' satisfaction depends on integrated efforts of suppliers, manufactures, and distributers; performance improvements of individual supply chain constituents may not be enough to achieve that goal. Even in the agricultural sector where new collective entrepreneurial strategies are emerging, the nature of these organizations generates decision-making problems due to the diverse concerns of their social base (Poole and Donovan, 2014). Every link in food supply chain involves human resources, so the researches on human behavior in supply chain refer to all links to understand the behavior of each link .As for researches in supply link of food supply chain (Cui *et al.* (2012) analyzed the reasons of farmers' being shortsighted, poor tendency for organic farming, and also the effects of uncompleted contracts and supervision barrier on farmer. (Wang *et al.* 2011) analyzed key elements that affect farmers' decisions and behaviors on using pesticide and chemicals in various farming process. In the researches in end consuming link, (Qiu *et al.* 2008) demonstrated that safe food consumption behavior is one of key solutions to food safety problems, in processing link, in transporting link, or in consuming. Within the food supply chain literature, It is, suggested that the competitive advantage of vegetable supply chains lies in networking by chain member according to supply chain management (SCM) . The network member ability to learn from each other and adapt to market changes increases coordination, leading to structural changes whereby the most efficient supply chains survive in a most competitive market (Hingley et al, 2002; Hollingsworth, 2004; Duffy, 2006)).The issue of coordination within food supply chains mainly lies in the effectiveness and efficiency of the chains in the competitive environment. However, the coordinative relations and structures within supply chains are basically invisible and need to be improved. The relationship between farmer, market, supplier, including social relations, needs to be studied empirically to analyze the effectiveness of food supply chain. Additionally, it is important to understand how chain level coordinative structures build up and bear on supply chain. The market relations supported chain operations both upstream and downstream in all chains. Wholesalers, multiple retailers who purchase food product from farmer and local outlets offered market access for both large and small food supply chains, to sustain in adverse condition of market. However, heavy competition between large multiple retailers increases their price sensitivity and turns them into global buyer alliances and local market turns to global market (Hollingsworth, 2004). The large supply chains must have for lower prices and better quality in their buyer relations, and the appropriate price signals were given upstream (from farmer to consumer). So far, small local suppliers who supplies food product to customer have access to large retailers and single supermarkets; otherwise local food will be sold through less accessible channels, limiting its growth .This practice may depend on the chain policy and the value given to selection and authenticity (Jones et al., 2004). Food safety has been considered an important unavoidable attribute of the product for consumers. In present times the concerns and requests of the consumer for healthy and safe food are increasing .The food safety movement and continuous effort to avoid the transfer of diseases to humans .An important driver for improvement would be the establishment of "whole chain" key performance indicators (Taylor, 2006).Other factors such as the policies and rules on environmental issues such as use of pesticides and proper irrigation method, changes in consumer attitudes towards the environment, purchasing organic food product, and the increasing regulation and competition regarding the quality and efficiency of production, are forcing the agri-food industry to formulate new management concepts and systems. In fact, the change in the industry focuses from the traditional objective on economic efficiency to a new focus on quality improvement and on reducing the negative impacts of production on environment.

2.3 Characteristics of demand in agri food chain

Analysis of the data from the six case studies revealed three key characteristics demand in the four sectors covered: variability in consumer demand, miss-alignment of demand and activity al(FAO,2011)

1)Variability in consumer demand: Variability in consumer demand was a feature of all of the chains studied; however there were significant differences in the degree of variability and in the causes of variability. Where customer demand was highly variable, managers often noticed that seasonality or unpredictable events such as climate changes were the reason. Although such events undoubtedly do have an impact, the research suggested that for many fresh food products, high variability in weekly consumer demand was most commonly caused by promotional policies.

2) Misalignment of demand and activity along the chain: there was also considerable and consistent evidence from the case studies of a fluctuation for demand and activity patterns to become misaligned along agri-food chains. There are two reasons for this:

3) Demand amplification: in which ordering staff at retail stores and ordering/inventory control algorithms in the retailer's centralized ordering systems tend to exaggerate changes in end consumer demand as they create orders for the supplier.

4) Supply-side effects: in which primary food production and further processing is driven by production efficiency targets related to product yield, batch sizes and inventory levels, rather than by a policy of producing in line with customer demand.

2.4 Type of food supply chain performance indicators

Frösen *et al*. (2013) cited that the ability to assess marketing performance for farmer in an accurate manner enhances business performance. Performance measurement has gained attention in the agri-food chains Chaowarut (2009); and Shen *et al*. (2013) used various performance measurements to measures the performance .The focus has been on the supply chain performance measures. Supply chain performance refers to the degree to which the supply chain fulfills the end-users (Customer) and the stakeholder's requirements concerning the relevant performance indicators at any point in time (Van der Vorst, 2011). Agri-food supply chain performance indicators are divided into four main categories: efficiency, flexibility, responsiveness and food quality. These four categories control the whole supply chain. Each of these main categories contains more detailed performance indicators .For small firms in emerging economies, research is necessary to understand what are the obstacles to enhancing sustainable chain performance (Etemad, 2013), and what are the appropriate strategies and structures, such as information sharing and collective organization, that might ease firm entry and overcome the SC constraints(Simichi levi,2003).The suggested performance indicators can be used at the organizational level as well as the supply chain level. This means that supply chain members, besides their own set of performance indicators have a common set of performance indicators within four main categories that help them to evaluate their own performance and the performance of the chain. These common set of indicators for complete supply chain can be identified as key performance indicators.

1) Efficiency measures how well the resources are utilized in the food supply chain (Lai et al., 2002). Effectiveness is defined as the psychological distance between what is expected to the result from the marketing program and the results returned from selling products to end user (Clark, 2000). It includes several measures such as production costs, profit, return on investment , inventory, quality of food item and farmer financial condition .

2) Flexibility indicates the degree to which the food supply chain can respond to a changing environment and extraordinary customer service requests (Bowersox and Closs, 1996; Beamon, 1998). It may include customer satisfaction, volume flexibility, delivery flexibility, reduction in the number of backorders and lost sales and condition of food (perishable) product during supply.

3) Responsiveness aims at providing the requested food products with a short lead time.. It may include fill rate, product lateness, customer response time, lead time, shipping errors, and customer complaints.

4) The specific characteristics of agri food supply chains are captured in the measurement framework in the category food quality. According to Aramyan *et al*. (2006), quality can be measured based on the either intrinsic or extrinsic indicators. The intrinsic indicators include; flavor, texture, appearance, shelf life and nutritional value. These are objective and directly measurable. While extrinsic attributes include; the amount of pesticide use, type of packaging material, use of biotechnology. The purchase of a product is based upon both intrinsic and

extrinsic attributes. According to Fischer, (2010), the quality can also be measured based on the marketing costs and product price The latter is based on the framework of food quality developed by Luning et al. (2002). Food quality is divided into product and process quality.

CHAPTER 3

RANKING OF CRITICAL SUCCESS FACTORS BY TOPSIS

3.1 Introduction

To effectively compete in the global market, SMEs of food supply must have effective supply chain management. Conflicting objectives and lack of coordination between supply chain partners may cause uncertainties in supply and demand. Therefore effective SCM is required to streamline the supply chain of SMEs. A number of studies have attempted to identify the CSFs of SCM such as Electronic Data Interchange (EDI), and Enterprise Resource Planning (ERP) systems .The key characteristic of agri food chains is the seasonality in production. This requires global sourcing (Marsden et al 2000). There is need to maintain product safety as result of increased consumer attention for both product and method of production. There is variability in process yield in terms of quantity and quality due to biological variations, seasonality and factors connected to weather, pests, and other biological hazards. The agrifood are more perishable, more sensitive to external influences (e.g. temperature, vibration, light), often of high monetary value, more demanding in terms of logistics and insurance (Fischer, 2010). The perishability of agricultural and food products requires efficient logistic processes, to move the product through the chain as rapidly as possible and to maintain valuable quality and safety characteristics (Bijman *et al.,* 2006).There it is necessary to find out critical success factor of food supply chain. Prioritization of critical success factor of food supply chain remains a major problem for decision maker.

3.2 Identification of critical success factors of food supply chain

CSF affect the food supply chain in serious way (Black,1996). Critical success factors for supply chain implementation have significant correlation with performance in terms of customer service and satisfaction, Critical success factors for supply chain implementation have significant correlation with performance in terms of innovation and growth, and Critical success factors for supply chain implementation have significant correlation with performance in terms of customer service and satisfaction. Various critical Success factors of food supply chain are shown in fig 3.1.

3.2.1 Information technology application : A significant challenge facing agri-food small and medium-sized enterprises (SMEs) has sustain growth in regional (rural, urban) and sometimes global market (Thomas et al, 2000b).Food packing and distribution companies use IT to automate delivery and billing, and retailers are striving to complete the implementation of scanner systems for fresh . The uneven adoption of IT along the farm-to retail chain, and across firms, points to potential strategic advantages for some firms. Delays in adopting IT could prove costly, because information that provides competitive advantages serves as a strategic resource (Sonka et al, 1988). Typical examples of IT for physical functions include the automation of ordering processes and payment mechanisms, scheduling of warehousing and delivery, and control systems for quality assurance in production IT is a valuable tool for creating a supply chain that is capable of rapid response, but it has its limits. The point-of-sale scanner is the key IT tool for tracking retail demand in the grocery

Industry. Over the past thirty years ICT technologies have been introduced in the agriculture and food sectors, improving the food production and its transportation to the end consumers (Nikkilä, et al . 2010).Some of the key challenges for ICT in the agri-food sector are related to information management, whether within specific domains or across the whole supply chain from farm to fork (Sørensen,etal,2010) .Small firms use many advertising and marketing to build relations with their customers and to attract . In recent years many SMEs have realized the importance of the Internet for customer relations by developing its interactive service (Saha et al,1994). For early Internet marketing content was important but more recently marketing professionals have realised that interactivity is critical to for build relationships with customer. There are three level of working.

- Informational level-:This is the most basic level and the Web site is fundamentally a means to provide the same information available through traditional marketing. This usually includes the nature of the enterprise.
- Transactional level-: A transactional Web site provides more than static information by enabling communication with the customer.

- Relational level-:The Internet comes to the fore over marketing at this level where an enterprise can develop interactivity with a customer .This enables the development of a continuous relationship from the original transaction.(Simmons et al,2003)

Material tracking is another application of IT the first international definition of tracking was given in ISO 8402 standard in 1987 (also assumed later in ISO 8402:1994 edition of the standard) as "the ability to retrieve history, use or location of an entity by means of recorded identifications". The entity may designate: an activity, a process, a product, an organization. Wang and Li (2012) leveraged the benefits of tracking and tracing technologies to develop a dynamic product quality assessment model that captures shelf-life features and product deterioration rates, for determining the appropriate pricing strategies and maximizing profit. Moreover, Beulens et al. (2005), in their study regarding the importance of establishing effective tracking and tracing systems, concluded that ICT and quality systems are easily installed and configured by each actor of supply chain .

Tracking of food also defines "the ability to identify by means of paper or electronic records a food product and its producer, from where and when it came, and to where and when it was sent" (FAO,2011). Food tracking has promoted the concept "from farm to fork", or in other words knowledge of the food chain from primary producer (farmer) up to the consumer, to help identify the cause of an event of major non-compliance related to product safety and to limit the expansion of negative consequences. Bar codes (including 2D): originally applied only to products in order to identify them in the marketing chain, have been used for several years for traceability purposes related to raw materials processing (Stancu, .2012):

Radio frequency identification (using RFID technologies): As the robustness of an AFSC is dictated by the efficiency of its echelons, the information gaps between stakeholders and their product expectations foster conflicts of interest. As a response, the adoption of Radio Frequency Identification (RFID) technology could secure the visibility requirements among the SC partners (Stadler,2005;Trienekens,et al 2011; Zhang & Li, 2012).

transmitters transmit energy in the form of radio waves through an antenna, so that when waves meet the label, it emits a radio signal that can be picked up by the transmitter and decoded to reveal the contained information; edible markers - to be applied directly on/in food, the marking should consist of an edible substance, generally recognized or scientifically proven to be safe for human consumption.

3.2.2 Education and training : training can be defined as (Bertolini et al.2007) A systematic process through which an organization's human resources gain knowledge and develop skills by instruction and practical activities that result in improved performance Attainment of education was found to have a positive relationship with the individual's attitudes towards change agents and as such favorable attitude to innovativeness. Most (50%) of the farmers has low level education, 20.0% of them attained tertiary education, 18.9%, 7.8%, and 3.3% of the farmers had secondary education, adult education and primary education respectively. Almost all the farmers had attained one type of education or the other. This finding is in accordance with Okwu *et al* (2007) who reported that an individual's level of education was found to affect his or her access, comprehension and adoption of modern agricultural practices. The effect of education on adoption had been argued by several researchers. Voh (2002) reported a positive and significant relationship between formal education and adoption of agricultural innovation. Additionally, that organization's training objectives should.

- Improve performance.
- Shorten the length of training time.
- Obtain better employee retention.
- Training and education also help in proper packaging and proper handling of food stuff.

It has been observed that of all the technological changes occurring in the traditional societies of the underdeveloped world, the most effective and the one that touches the livelihood of the people and their societies positively have been the changes in modes of communication (Nwachukwu et al, 2005).Mass media channels are often the most rapid and efficient means to inform the farmer about the existence of an innovation, which is to create an awareness or knowledge of the innovation. In recent decades, the widespread use of the mass media has resulted in heightening the level of public knowledge in different fields, due to their wide and vast range of viewers. Among the different modes of communication, radio has been acknowledged as a powerful communication tool (Nazimi and Hasbullah, 2010) that has proved to be the most effective media in promoting agriculture and the development in the rural areas (Nakabugu, 2001). FAO (2001) acknowledged radio as the most important communication medium for communicating with the rural populations of the developing countries. Adequate and relevant information from any means of communication is one of the key requirements for increased productivity, increased income and therefore leads to poverty reduction among the food producers (Nkrumah, 2008).Fare trade is another medium for awaking farmer .It is described as social movement for gathering information from various sources .Fare trade plays important role in assist farmer regarding organic farming and encouraging consumer for conscious consumption and organic use .Farmer who grows cereals ,pulse ,oil seed can directly deal to food manufacturer. Other food awareness program organized under ISO 22000.

3.2.3 Logistic and warehousing: the role of warehouses, as inventory holding and the servicing of customer orders from that inventory are key warehouse functions.(Taylor,2006,Childhouse,2003).Wang, and Liang (2012) developed an integrated approach for modeling the total AFCS inventory costs and concluded that the deterioration rate of the final products

can increase the total inventory costs by more than 40%. Other roles for warehouses are being

- Transshipment facilities, which are used to change transport mode (e.g. from large line-haul vehicles to smaller delivery vehicles)

Assembly facilities, where the final packaging of the food product to individual customer requirements can take place. A cold chain is a temperature–controlled Supply chain. An unbroken cold chain is an uninterrupted series of storage and distribution activities which maintain a given temperature range. It is used to help extend and ensure the shelf life of products such as fresh agricultural produce ,seafood, frozen food, Such products, during transport and when in transient storage, are called cool cargo**.** Unlike other goods or merchandise, cold chain goods are perishable and always en route towards end use or destination, even when held temporarily in cold stores and hence commonly referred to as cargo during its entire logistics cycle.(Zu. 2009). There are two terms often used to describe food that is produced for human consumption but does not end up being consumed. This is described as food loss when it occurs during agricultural production, post-harvest handling or processing of products, and as food waste when it occurs at the end of the food chain during distribution, retail sale and final consumption. Food losses include crops destroyed by drought or pests, and wastes from food processing such as fruit and vegetable peel. This is largely unavoidable. In contrast, food waste is linked to human action and could potentially be avoided through improved efficiency and planning (Mason,et al,2011). the packaging techniques along food SCs, from raw materials to final products, are strongly connected with the delivered quality to consumers and thus have been thoroughly investigated in the literature (e.g. ; Restuccia et al., 2010; Vitner, Giller, & Pat,2006)

For the purpose of this report packaging is divided into:

1. Primary packaging: the retail or consumer pack that contains the sales unit (e.g. a plastic bag, glass jar or steel can, or a plastic crate for loose fresh produce).

2. Secondary/tertiary packaging: additional layers to protect and contain the primary packs during distribution (e.g. a corrugated box, plastic or timber pallet, plastic crate for processed foods, or stretch wrap).

Warehousing involve material handling, it is the movement, protecting, storage and control of food product throughout manufacturing, warehousing, distribution, consumption and disposal. It includes a wide range of manual ,semi automated and automated equipment system .

3.2.4 Behavior issues: Theocharopoulos et al. (2012) examine the factors affecting the decision of farmers to adopt or not to adopt organic farming and integrated crop management in food sector. Technical and fact that there is a strong commitment of some SC actors and weak or no commitment of others reveals their different perceptions towards new opportunities such as organic food. Nyaga *et al*. (2010) also highlighted similar behavior with respect to different perspectives on buyer-supplier

collaborative relations economic reasons and the shortage of scientific support networks are factors affecting the decision; subsidies do not seem to play an important role in the decision to convert to integrated crop management, but these factor affect the decision to adopt organic farming, less so than environmental and ideological aspects. Bravo et al. (2012) address farmers ‘satisfaction with organic certification and its determinants.

Organic farming is a form of agriculture that relies on techniques such as crop rotation green manure, compost and biological pest control. Depending on whose definitions used, organic farming uses fertilizers and pesticides (which include herbicides, insecticide sand fungicides). If they are considered natural (such as bone meal from animals or pyrethrum from flowers), but it excludes or strictly limits the use of various methods (including synthetic petrochemical fertilizers and pesticides; plant growth regulators such as hormones; antibiotic use in livestock; genetically modified organisms(Paul,2011).The Farmer-to-Consumer Direct Marketing Act of 1976 (Brown 2001), farmers markets have been growing in number and popularity, providing valuable opportunities for thousands of full- and part-time farmers (Kremen,et al 2004). Various reasons for their continued growth have been advanced in the literature (Fitzgerald 2004) ranging from health conscious consumers purchasing more fresh fruits and vegetables to food safety concerns about foods brought in from distant parts of the country or from overseas. So consumer should be aware of farming process and food quality. the growth in the number of farmers markets, in farmers using the markets, and in customers using the markets indicates that farmers markets are important to farmers, customers, and the communities in which the markets operate (Payne 2002). In a survey it has been found that freshness and quality, followed by price, are the most important factors that draw shoppers of all income levels to public markets. Lower-income consumers appear to be more interested in the basics of quality and price than are middle class consumers, who more often cited “atmosphere,” “variety of produce,” and “buying from the farmer.” Both middle- and lower-income consumers were interested in organically grown produce.

3.2.5 Quality control of food (vegetable, fruit): Today's consumer has become increasingly concerned about the quality and safety of food and the negative effects of bio-industrial production (Murdoch et al,2000,Terziovski,2011). Even though food products seem to be safer than ever before, from a technical point of view and due to many quality control programs, the safety perception of consumers has decreased significantly.

At the same time, food sectors have rapidly internationalized. Market demand is no longer confined to local or regional supply. Retailers and food industries now source their products from all over the world, transforming the food industry towards an interconnected system with a large variety of complex relationships. To deal with these challenges, companies around the world are increasingly using standard quality assurance systems to improve the quality and safety of food products and production processes. Quality assurance systems enable the application and verification of control measures intended to assure the quality and safety of food. They are required at each step in the food production chain to ensure safe food and to show compliance with regulatory and customer requirements. Governments have an important role in providing policy guidance on the most appropriate quality assurance systems and verifying/auditing their implementation as a mean of regulatory (FAO, 2002).

Quality and safety characteristics of food production

Food products and production processes have a number of specific characteristics that influence product quality and quality assurance in production processes (Ried,2010, Van de vorst, 2000):

1) Quality variation between different producers and between different lots of produce, due to, e.g., weather conditions, biological variation and seasonality, but also as a possible result of variations in production.

2) Perishability of produce and fresh products. For many materials shelf-life constraints apply.

3) Production yields are often uncertain due to, for example, weather conditions and quality variation within and between lots.

4) There are special demands for storage and transportation, such as cooling facilities and hygienic measurements.

Since the 1990s many private food quality and safety standards have been developed. The major aims of private food safety standards are :

1) To improve supplier standards and consistency, and avoid product failure;

2) To eliminate multiple audit of food suppliers–manufacturers through certification of their processes;

3) To support consumer and retailer objectives by transferring their demands to parties upstream the chain;

SQF aims at quality assurance from a total supply chain perspective. The SQF program is based on the principles of HACCP, ISO-9000 series norms and Quality Management Systems. SQF distinguishes between two norms. SQF 1000 focuses on primary producers, all other companies are certified according to SQF 2000. An important difference between both norms is that SQF 2000 companies must work according to HACCP. SQF is developed in Australia and is internationally well accepted. An advantage is that SQF can be included in the product label.

Instrument innovation in agriculture is a system analysis of the instruments that support innovation in agriculture was carried out in 2010. The results show that the available incentives mainly support actors on the one hand and knowledge and learning processes on the other. The coherence of the instruments is judged to be good, but there is a lack of instruments that really contribute to innovation (Feder et al,1985). More at-tension is needed for collaboration with actors outside agriculture (e.g. in the food chain)

3.2.6 Market strategy: Marketing performance is a multidimensional construct (Sampiao *et al*., 2011,Neely,2005). It is composed of effectiveness, efficiency and adaptability (Morgan *et al*., 2002). Marketing performance concerns market place awareness and reactions to the realized positional advantage. Marketing performance can be defined from three different perspectives; customer, competitor and internal perspectives(Vorlaufer et al,2012) Rust *et al*., (2004a), describes marketing performance as consists of sequentially of customer impact, market impact, financial impact and impact on firm value. Academic discussion of farmers ‘markets has tended to focus on the socialization and economization of markets, such as the role of markets in the lives of older consumers (Szmigin et al., 2003) and in building networks of local producers and consumers (Holloway et al., 2007), and in the generation of new businesses (;Ulaga,2002). food market is a place where local growers, farmers and artisan food producers sell their wares directly to customers. Vendors may only sell what they grow, farm, pickle, preserve, bake, smoke or catch themselves from within a defined local area. The market takes place at a public location on a regular basis (FMNZ, 2010; Hall et al., 2008,). Aramyan et al.2007,analyse that food market is influenced by many different forces – e.g. sociological (fewer children mean less demand for certain products), government regulations, international trade conditions, science and technology, weather and other conditions influencing harvest conditions, economic cycles and competitive conditions Farmers' markets are therefore predominantly temporary, flimsy retail environments,

Constructed for the day and then dismantled, comprised of simple tables and pergolas, crates and banners. Vendor development is an evolution in supply chain management. There is a growing interest in generating approaches for meaningful development of suppliers so that business could snatch long-term strategic initiatives by developing effective partnerships with suppliers. Vendor development places priority on vendor improvement through training, co-developing product, innovation, improving capacity, delivery lead-time and quality of product of their counterparts (D'Lima, 2001) .The new conceptual framework on vendor structures that consists of three primary dimensions(Yu,2012)

(1) Vendor structure scope.

(2) Vendor structure relationship.

(3) Vendor structure focus

Auer (2000) discussed the issue of who pays for a software vendor's development environment usually surfaces in negotiations. He described that the development environment costs usually include additional charge for hardware, operating system software, network connections and services that are needed to build the software ordered.

3.2.7 Network optimization: The optimization of the transport system of AFSCs has been addressed by many researchers. Higgins et al. (2006) proposed a model framework to improve the efficiency of both the harvesting and transport operations. Boudahri, Bennekrouf, and Sari

(2011) proposed a model for the design and optimization of the transportation network of an AFSC .In the context of the ASC, we have identified four main functional areas: production, harvest, storage, and distribution. Decisions made in production include those related to cropping, such as the land to allocate to each crop, timing of sowing, and the determination of resources required for growing the crops. During harvest, some of the decisions that need to be made include the timing for collecting the crops from the fields and the determination of the level of resources needed to perform this activity. Some other decisions made at harvest include the scheduling of equipment, labor, and transportation equipment. Sometimes these decisions also involve the scheduling of the packing or processing plant. The third function is storage, which includes the inventory control of the agric-foods, which is required when the products need to be stored before or during their distribution. Some storage-related decisions also include the amount to store and sell in each planning period and how to position the inventory along the supply chain. Finally, the distribution function involves moving the product down the supply chain to deliver it to the consumers. The decisions associated with distribution include selecting the transportation mode, the routes to use and the shipping schedule to deliver the product distribution. Proper Linking between Farmer and Market need for network optimization. By Proper is Linking Less Food Material Will Wastage And Less Transportation Cost.. A major subset of value chain development work is concerned with ways of linking producers to companies, and hence into the value chains. While there are examples of fully integrated value chains that do not involve small holders. The great bulk of agricultural value chains involve sales to companies from independent farmers. Such arrangements frequently involve contact farming in which the farmer undertakes to supply agreed quantities of a crop or livestock product, based on the quality standards and delivery requirements of the purchaser, often at a price that is established in advance. Companies often also agree to support the farmer through input supply, land preparation, extension advice and transporting produce to their premises .

Work to promote market linkages in developing countries is often based on the concept of “inclusive value chains”, which usually places emphasis on identifying possible ways in which small-scale farmers can be incorporated into existing or new value chains or can extract greater value from the chain, either by increasing efficiency or by also carrying out activities further along the chain. Choosing the right global food material supplier is crucial in successful food supply chain. Developing a process flow for the supplier selection process will play an important role in determining how to select a high-quality supplier during the supplier selection process, many factors need to be analyzed. Strategic long-term relationships and integration with suppliers is one of the key aspects in managing SCs, including choice of the right suppliers (Prajogo *et al.*, 2012). A food manufacturer must evaluate potential suppliers according to some of the following characteristics when selecting a packaging material supplier (Levary, 2007):

1) Transportation cost.

2) Safety of food product during transportation.

3) Cost of quality. COQ is defined as the sum of the costs incurred across a supply chain in preventing poor quality of product and/or service to the final consumer, the costs incurred to ensure and evaluate that the quality requirements are being met and any other costs incurred as a result of poor quality. Several studies indicate that COQ is approximately 30 percent of total manufacturing costs (Srivastava, 2008).

Vendor selection out of alternative vendor is another parameter of network optimization .Vendor evaluation is one of the most interesting and most talked about subjects in the area of organizational strategic planning among senior executives and entrepreneurs around the globe. Today’s High-technology market poses a greater challenge to both customers and vendors. Buyer firms are frequently affected by “mass confusion” and “customer bewilderment” and at the same time vendor choice becomes increasingly challenging. vendor can be selected on the following basis.

1) Track-record of defect-free delivery.

2) Responsiveness to food quality problems.

3) Vendor’s adherence to NPI development schedules.

3.2.8 R&D: the utilization of precision agriculture technologies (i.e. satellite imagery and geospatial tools) has emerged lately as a means to promote farming efficiency and environmental sustainability (e.g. Aubert, et al, 2012 ,Roger 1995) .The financial planning and investments regarding farming operations (i.e. crop selection, field infrastructure and machinery acquisition) are of pivotal importance as they further define the production capacity, performance and financial viability of the stakeholders involved in the entire SC. Programmed started by the Agricultural Research and Development Institute (ARDI) in the 1980'swas reported to offer some promise in improving the establishment of food industries and related inputs through (R&D). The advantages of this R&D can be extended should all the food-manufacturing industries be covered in the future. This will help in enhancing the active role of the food-manufacturing sector and its development .Besides this development, R&D in other fields such as the biotechnology of improving food crops genetically, will help to improve the characteristics of the raw materials for the food manufacturing industry. These target characteristics includes superior texture, color, flavor and nutritional value, among others (Vanloquren;2009). Transgenic plants can increase desirable processing characteristics such as higher solids levels, inhibition of enzymatic action, delayed ripening and longer shelf life (Yeoh et al 1995).

Our current trajectory with food is not sustainable; the world population is over 9 billion .this growing population making strain on food industry. So in past few decades scientific and technological advancement have benefit farmer in the industrialized world by driving agriculture production (IFAD,2011).Therefore it is the need for farmer that they will aware of new technology such as modern irrigation practice ,crop management product, fertilizers, post harvest loss solution, improved seed variety, mobile technology for agriculture information etc. the matching of soil types with the desired crops, the design of crop rotations, irrigation development and fallow systems, and resource utilization balance among multiple farms are key decisions in order to deploy effective and sustainable AFSCs (Glen & Tipper, 2001;Silva, & Pereira, 2010; , Schmid and Schneider, 2011) These need large investment in farming. Hybridization is a tool that farmer used to develop high yielding seeds .It consists of crossing two or more crop to produce hybrid crop with favorable traits ,resulting from combination genes from selected parent. This also improve crop resistance against pest .crop compete with thousand of species of weeds, plant casting insect. Gillespie et al. (2007) .Indicated that unfamiliarity, non-applicability, high cost are some of the reason why seemingly beneficial technologies do not get adopted by farmers. It has been found that as long as information level on technology is above the threshold level, farmers would consider adopting a technology.

3.2.9 Government policy and support :government policy and guidelines are used for transportation cost for farmer and supplier, policy regulate revenue given by farmer to distributor (Lagrosen,.2007, van der Vorst 2011) provided a taxonomy of the appropriate governance mechanisms and organizational arrangements tailored to the transparency demands of the different AFSC partners (i.e. the government, food companies, and consumers. Common Agricultural Policy which provides substantial expenditure through different forms of direct payments to farmers (€2,315 million in 2012) as well as crop-specific market measures (€67 million), more than one-third of which was spent on fruits and vegetables (European Commission, 2014).The Policy is defined as a set of inter-related actions concerning the setting "of goals and the means of achieving them within a specified situation"4, based on a set of preferences and choices. Policy is thus not just a decision, but a process of action. Ideally policies are made in the framework of a strategy, which "constitutes both a vision of what the sector should look like in the future and a roadmap how to fulfill this vision including public investment, used to produce related desired outcomes. Budget allocations policy often needs resources to implement both policy measures and institutional arrangements. Budget allocations are therefore the real engine of the policy, especially when specific interventions are foreseen (building roads, dams, providing subsidies, building capacities, etc.). In the context of an agricultural policy that seeks to increase production as a policy objective, the government may choose one or more of the following measures: input subsidies, seed distribution, guaranteed price, public purchase of food, etc. According to MAF's Food and Agricultural Policy Framework (FAPR - November 2006);

MAF's Strategic Plan 2007-2011 (June 2007). Goals:

• Food self-sufficiency/self-reliance by 2011;

• Contribution to reduction of poverty by 30 percent by 2011; and

• contribute to increasing GDP by 25 percent by 2011.

3.2.10 Environmental aspect: Mintcheva (2005) argued that environmental issues cannot be addressed separately at each step of a food SC and instead proposed a set of indicators that could be embedded into an integrated environment policy framework for such SC networks. The food industry encounters pressures not only in terms of nutritional value and safety, but also from environmental concerns (Kohls and Uhl,2001)

a) Energy use: The amount of energy used during the production process i.e. amount of electricity used during irrigation, amount of fuel used in transportation.

b) Water use: The amount of water used during the production process The ratio of liters of water used per square meter of land under the vegetables.(Pandey et al 2006)

c) Pesticide use: A permitted amount of pesticides used in the production process The amount and the frequency of pesticide use complying with standard regulations. Pesticides, fertilizers, and other chemicals: application rates per acre; actual and potential harmful effects on land, water, vegetation, animals, and man in different areas; present and future trends in supply and demand; alternatives for those causing environmental problems; and suitable substitutes for those causing environmental problems(Berry ,2006).

Table 3.1: **Factors used for ranking by topsis**

Factor	Refrences
1.IT application • **Material tracking** • **Internet** • **Bar coding of product**	(Sparkes and Thomes ,2000,Nikkila,2010,Sorensen,2010, FAO,2004,Stancu,2012)
2. Education and training • **Training of farmers** • **Awarness program** • **Trade fair for gathering information**	(Bertolini ,etal,2007,Nwachukwu and Onuekwusi,2005,Nazimi and Hasbullah,2010,Nkrumah,2008,)
3.Logistic and warehousing • **Cold storage** • **Material handling** • **Packaging**	(Yu wang & Liang 2012,Rushton et al,2006,Zu,X,2009,Parfitt,etal,2010,Masone tal,2011),
4.R&D • **Awareness of new technology(developi ng of new technology of farming)** • **Improving Scientific tempor for cultivation(hybrid crop)**	(Lagrosen,2007,Yeoh et al ,1995,IFAD,2011,ICP,2011, Gillespie,2007,Schmid & Schiender,2011)
5. market strategy • **Vendor development** • **Market analysis**	(Sampio,2011,Scmigin et al ,2003,Holloway et al,2007,Guthrie et al,2006,FMNZ,2010,Hall et al,2008,Vorlaufer,2012)
6. Quality control • **ISO standard for food products** • **Food safety**	(FAO,2002,Ried,2010,, van der vorst ,2000,Teziovski,2011,Feder et al ,1985)

• **Quality standard** • **Agriculture instrument innovation**	
7. Network optimization • **Alternative supply network** • **Alternative vendor** • **Alternative supplier** • **Proper linking of farmer and market**	(Boudhari et al 2011,Srivastava,2008, Levary,2007,Prajago et al 2007)
8.Behavioural issue • **Motivate farmer for organic farming** • **Behaviour of Customer toward farming** • **Attitude of retailer towards the farmer**	(Theocharopoulos et al,2012 ,Brown,2001, Bravo et al 2012,Paul,2011,Fitzgerald,2004,Payne,2002,Payne,2002)
9.Govrment policy and support • **Government policy** • **Government budget**	(Lagrosen,.2007 , European commission,2014,Vander vorst,2011)
10.Enviromental awareness • **Energy use** • **Water use** • **Pesticides us**	(Mitcheva,2005, Kohls and Uhl,2001,Pandey,2006, Berry ,2006)

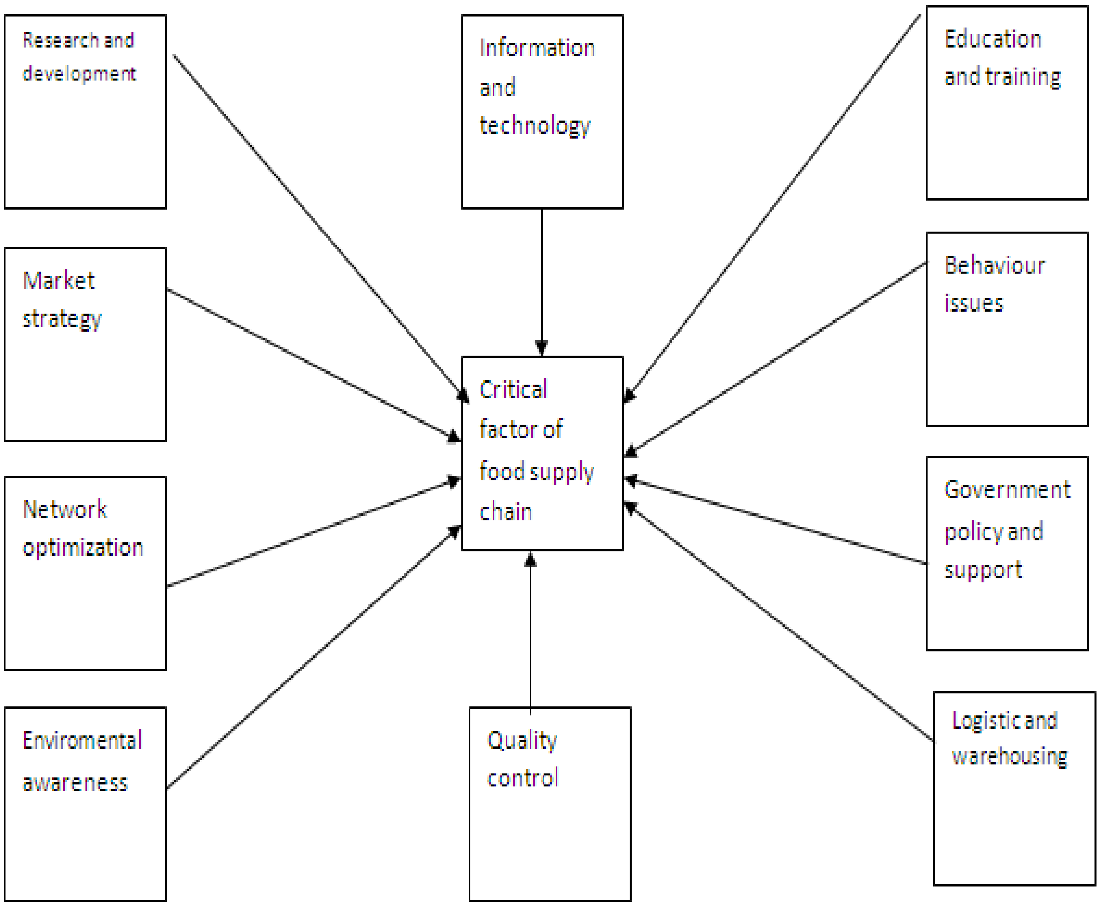

Fig .3.1: The identification of critical success factors

3.3 Research methodology

Following steps have been used in TOPSIS to calculate the rank.

Step 1:

Calculate the normalized decision matrix as:

$R = [\ r_{ij}\ ]$ .... (1)

Where

$$r_{ij} = \frac{X_{ij}}{(\sum X_{ij}^2)^{1/2}}$$

R is normalized matrix of element r_{ij}.

Step 2:

Construct the weighted normalized matrix by multiplying the elements by weights of corresponding criteria.

$V_{ij} = r_{ij} * W_j$ .... (2)

Step 3:

Find out the positive and negative ideal solutions as V_i+ and V_j^- respectively by finding the maximum and minimum values of weighted normalized elements in each column.

V_i+ = Max. weighted normalized elements in each column .... (3)

V_j^- = Min. weighted normalized elements in each column .... (4)

Step 4:

Calculate the separation measures for each alternative.

$S_i+ = [\sum(V_{ij} - V_i+)2]1/2$ .... (5)

And

$S_i^- = [\sum(V_{ij} - V_j^-)2]$ .... (6)

Step 5:

Calculate the relative closeness to ideal solution using the formula:

$C_i+ = \frac{s_i^-}{s_i^+ + s_i^-}$ .... (7)

3.4 Case Application:

We studied the three companies which belong to the food company. These companies were certified by ISO 9001:2000 certificate. We provide the list of critical success factors to the decision makers of these companies and told them to give the rating of these critical success factors on five point scale. A factor which is very important, give them five points and a factor which is least important give them one point.

3.5 Findings and discussion:

Three decision makers give the score to the critical factors which is shown in table 3.1. After that we normalized the matrix. Table 3.2 shows normalized decision matrix. Then we multiply the normalized matrix to the weight. Weight is given by the experts. Table 3.3 shows the weighted normalized matrix. Then we find out the separations of each alternative. Table 3.4 shows the positive ideal solution and table 3.5 shows the negative ideal solution for each alternative. Then we find out the separation from positive ideal solution which is shown in table 3.6 and separation from negative ideal solution in table 3.7. Table 3.8 shows the relative closeness to ideal solution. Minimum distance to the ideal solution has most critical factor and maximum distance to the ideal solution is least critical factor. Table 3.9 shows the rank of alternatives which depend upon the distance from ideal solution

Score provided by three decision maker

Table 3.2: Score provided by three Decision makers

CRITICAL SUCCESS FACTOR	**DM1**	**DM2**	**DM3**
Education and training	10	10	8
Market strategy	8	6	6
Environmental awareness	8	8	10
Quality control	10	8	10
Research and development	8	6	10
Network optimization	6	6	10
Behavior issues	6	8	6
Government policy and support	8	8	10
Logistic and warehousing	8	8	8
IT application	10	8	6

By using equation 1, calculate normalized decision matrix

Table 3.3: Normalized decision matrix

CRITICAL SUCCESS FACTORS	**DM1**	**DM2**	**DM3**
Education and training	0.3802	0.4110	0.2949
Market strategy	0.3041	0.2466	0.2212
Environmental awareness	0.3041	0.3288	0.3687
Quality control	0.3802	0.3288	0.3687
Research and development	0.3041	0.2466	0.3687
Network optimization	0.2281	0.2466	0.3687
Behaviour issues	0.2281	0.3288	0.2212
Goverment policy and support	0.3041	0.3288	0.3687
Logistic and warehousing	0.3041	0.32	0.2949
IT application	0.3802	0.3288	0.2212

By using equation 2, calculate weighted normalized decision matrix

Table 3.4: Weighted normalized decision matrix

CRITICAL SUCCESS FACTORS	**DM1(0.4)**	**DM2(0.2)**	**DM3(0.4)**
Education and training	0.1520	0.0821	0.1179
Market strategy	0.1216	0.0493	0.0884
Enviromental awareness	0.1216	0.0657	0.1474
Quality control	0.1520	0.0657	0.14744
Research and development	0.1216	0.0493	0.1474
Network optimization	0.0912	0.0493	0.1474
Behaviour issues	0.0912	0.0657	0.0884
Goverment policy and support	0.1216	0.0657	0.1474
Logistic and warehousing	0.1216	0.0657	0.1179
IT application	0.1520	0.0657	0.0884

By using equation 3 and 4, calculate the ideal solution and negative ideal solution.

Table 3.5: Positive Ideal solution

DM1	DM2	DM3
0.1520	0.0821	0.1474

Table 3.6: Negative ideal solution

DM1	DM2	DM3
0.0912	0.0493	0.0884

By using equation 5, calculate separation from positive ideal solution

Table 3.7: Separation from positive ideal solution

CRITICAL SUCCESS FACTORS	**S_i+**
Education and training	0.029488
Market strategy	0.074055
Enviromental awareness	0.034571
Quality control	0.01644
Research and development	0.044788
Network optimization	0.069141
Behaviour issues	0.086302
Goverment policy and support	0.034571
Logistic and warehousing	0.045439
IT application	0.061225

By using equation 6, calculate separation from Negative ideal solution

Table 3.8: Separation from Negative ideal solution

CRITICAL SUCCESS FACTORS	S_i^-
Education and training	0.075167
Market strategy	0.030411
Enviromental awareness	0.068362
Quality control	0.086302
Research and development	0.066356
Network optimization	0.058977
Behaviour issues	0.01644
Goverment policy and support	0.068362
Logistic and warehousing	0.045439
IT application	0.063005

By using equation 7, calculate relative closeness to ideal solution.

Table 3.9: Relative closeness to the ideal solution

CRITICAL SUCCESS FACTORS	**C_i+**
Education and training	0.718233
Market strategy	0.291111
Enviromental awareness	0.664144
Quality control	0.839988
Research and development	0.597029
Network optimization	0.460332
Behaviour issues	0.160012
Goverment policy and support	0.664144
Logistic and warehousing	0.5
IT application	0.507165

Rank the alternatives according to the preference order as C_i+. Shortest distance to the ideal solution shows the best alternative among all. The relationship between alternatives reveals that any alternative which has longest distance to negative ideal solution is guaranteed to have shortest distance to ideal solution.

Table 3.10: Rank of critical success factors

CRITICAL SUCCESS FACTORS	**C_i+**	**RANK**
Education and training	0.718233	2
Market strategy	0.291111	8
Environmental awareness	0.664144	3
Quality control	0.839988	1
Research and development	0.597029	4
Network optimization	0.460332	7
Behaviour issues	0.160012	9
Government policy and support	0.664144	3
Logistic and warehousing	0.5	6
IT application	0.507165	5

3.6 Results and discussion

According to TOPSIS analysis, alternative is selected based on their closeness coefficient. So quality and control is the most critical factor in food supply chain. Supply chain will fail in if better food product quality will not achieve. Education and training is ranked at number 2. So education and training is also a important critical factor either internal or external. Environmental awareness, government policy &support at 3. So government budget and proper technique for farming is necessary. Research and development at 4. As the requirement of food product is growing with population so new technology has to be adopted for farming process. We continuously improve our product quality with the help of R&D.IT application at 5. ITC technology is used in food tracking and testing so it need to be improved. Logistic and warehousing at 6. LW helps in proper cold storage of food product otherwise it will waste before delivery. Network optimization at 7. It is used for reducing time during transportation and selecting alternative supply chain. Market strategy is at 8 .MS is used for analyzing the market environment. Behaviour issues at 9.

3.7 Conclusion

Above analysis shows that critical success factors are very important for food supply chain. With the help of TOPSIS method, ranked the critical success factors. Quality control of food product has highest rank and behavior issue has lowest rank. Next chapter will describe selection of best food supply chain using fuzzy ahp.

CHAPTER 4

SELECTION OF FOOD SUPPLY CHAIN USING FUZZY AHP

4.1 Introduction

Ainapur et al. (2011) argues that optimizing supply chains activities is critical to all industries since it saves money, increases through put, decreases inventory levels and increases revenues, thereby improving the organizations financial status. Therefore different firms will attempt to realign their activities in way that will maximize revenue and minimize cost. There are four major goals pursued by retailers through the use of food supply change management: (1) lowered operating costs, (2) decreased procurement costs, (3) reducing marketing costs, and (4) lower distribution costs. All of the above will help to link Small holders to markets and therefore move upward from local to provincial, national and in the extreme to international markets. According to Shukla et al. (2011) supply chain involves the cost to convey the information, produce components, store them, transport them, and transfer funds. .

He argues that supply chain that adopt result oriented programs aim at making improvements in their supplier`s product quality, delivery and cost reduction while process oriented programs aims at continuous improvement of supplier capability. This requires establishment of long run relationship between the buyer and supplier. Hence competitive analysis of food supply chain is done to analyze all factors . According to (Ambastha,et al,2004),competitiveness is the supply chain ability to provide quality and healthy food product in shorter lead time than other supply chain in market. Competitiveness of supply chain depends on its ability to performance in all field such as quality of food product ,shorter lead time ,better condition during transportation ,flexibility to fulfill varying demand (Cachon et al,2004).To achieve these objective vague data need to be analyze by fuzzy sets theory.

4.2 Literature review

An integrated supply chain has an advantage on the competitiveness of the individual companies. As a result, the chain–chain competition has started to take over the enterprise–enterprise competition (Koha etal,2006). A number of firms have realized the potential of SCM in day-to-day operations management. In this section, factors of supply chain competitiveness are identified and from the opinions of experts from industries and academia. These factors are further grouped under three main factors, assets, processes, and performance. Assets and processes consist of four sub-factors each and Performance consists of three sub-factors (Singh etal,2014).

Food Supply chain selected on basis of different factor .These factor can be further classified into three group such as asset, process, performance as shown in fig 4.1.

4.2.1 Assets: It can be defined as inherited (natural resources) or created infrastructure in the firm to achieve economic gain from sales to customer. IT is very important factor in any food supply chain. Over the past thirty years ICT technologies have been introduced in the agriculture and food sectors, improving the food production and its transportation to the end consumers (Nikkilä, et al . 2010.) tools Some of the key challenges for ICT in the agri-food sector are related to information management, whether within specific domains or across the whole supply chain from farm to fork (Sørensen,etal,2010).Small firms use many advertising and marketing to build relations with their customers and to attract the customer. Material tracking is another application of IT .The first international definition of traceability was given in ISO 8402 standard in 1987 (also assumed later in ISO 8402:1994 edition of the standard) as “the ability to retrieve history, use or location of an entity by means of recorded identifications”. The entity may designate: an activity, a process, a product, an organization .The tracking of food defines “the ability to identify by means of paper or electronic records a food product and its producer, from where and when it came, and to where and when it was sent” (FAO,2004).Wang and Li (2012) leveraged the benefits of tracking and tracing technologies to develop a dynamic product quality assessment model that captures shelf-life features and product deterioration rates, for determining the appropriate pricing strategies and maximizing profit .Food traking has promoted the concept “from farm to fork”, or in other words knowledge of the food chain from primary producer (farmer) up to the consumer, to help identify the cause of an event of major non-compliance related to product safety and to limit the expansion of negative consequences. Bar codes (including 2D): originally applied only to products in order to identify them in the marketing chain, have been used for several years for traceability purposes related to raw materials processing (Stancu, A. 2012):

Radio frequency identification (using RFID technologies).In this transmitters transmit energy in the form of radio waves through an antenna, so that when waves meet the label, it emits a radio signal that can be picked up by the transmitter and decoded to reveal the contained information; edible markers - to be applied directly on/in food, the marking should consist of an edible substance, generally recognized or scientifically proven to be safe for human consumption. The role of warehouses, as inventory holding and the servicing of customer orders from that inventory are key warehouse functions..Wang, and Liang (2012) developed an integrated approach for modeling the total AFCS inventory costs and concluded that the deterioration rate of the final products can increase the total inventory costs by more than 40%. Other roles for warehouses are being Transshipment facilities, which are used to change transport mode (e.g. from large line-haul vehicles to smaller delivery vehicles) . Zu, .2009 there are two terms often used to describe food that is produced for human consumption but does not end up being consumed. This is described as food loss when it occurs during agricultural production, post-harvest handling or processing of products, and as food waste when it occurs at the end of the food chain during distribution, retail sale and final consumption. Food losses include crops destroyed by drought or pests, and wastes from food processing such as fruit and vegetable peel. This is largely unavoidable. In contrast, food waste is linked to human action and could potentially be avoided through improved efficiency and planning (Mason,etal,2011). The packaging techniques along food SCs, from raw materials to final products, are strongly connected with the delivered quality to consumers and thus have been thoroughly investigated in the literature .Cold chain is a temperature–controlled Supply chain. An unbroken cold chain is an uninterrupted series of storage and distribution activities which maintain a given temperature range. It is used to help extend and ensure the shelf life of products such as fresh agricultural produce seafood, frozen food. R&d is another factor for growing supplying chain .The advantages of this R&D can be extended should all the food-manufacturing industries be covered in the future. This will help in enhancing the active role of the food-manufacturing sector and its development. Besides this development, R&D in other fields such as the biotechnology of improving food crops genetically, will help to improve the characteristics of the raw materials for the food manufacturing industry. These target characteristics includes superior texture, color, flavor and nutritional value, among others. Transgenic plants can increase desirable processing characteristics such as higher solids levels, inhibition of enzymatic action, delayed ripening and longer shelf life (Yeoh et al 1995). The utilization of precision agriculture technologies (i.e. satellite imagery and geospatial tools) has emerged lately as a means to promote farming efficiency and environmental sustainability (e.g. Aubert, et al, 2012 ,Roger 1995). Our current trajectory with food is not sustainable, the world population is over 9 billion .this growing population making strain on food industry. So in past few decades scientific and technological advancement have benefit farmer in the industrialized world by driving agriculture production (IFAD,2011).Therefore it is the need for farmer that they will aware of new technology such as modern irrigation practice ,crop management product, fertilizers, post harvest loss solution, improved seed variety, mobile technology for agriculture information etc. the matching of soil types with the desired crops, the design of crop rotations, irrigation development and fallow systems, and resource utilization balance among multiple farms are key decisions in order to deploy effective and sustainable AFSCs (Glen & Tipper, 2001;Silva, & Pereira, 2010; , Schmid, & Schneider, 2011). Among the different modes of communication, radio has been acknowledged as a powerful communication tool (Nazimi and Hasbullah, 2010) that has proved to be the most effective media in promoting agriculture and the development in the rural areas (Nakabugu, 2001). FAO (2001) acknowledged radio as the most important communication medium for communicating with the rural populations of the developing countries: training can be defined as (Bertolini et al.2007) a systematic process through which an organization’s human resources gain knowledge and develop skills by instruction and practical activities that result in improved performance Attainment of education was found to have a positive relationship with the individual's attitudes towards change agents and as such favorable attitude to innovativeness

.4.2.2 Processes: To improve the performance of food supply chain various process has to taken. Quality control plays major role in process. Today's consumer has become increasingly concerned about the quality and safety of food and the negative effects of bio-industrial production (Murdoch et al, 2000, Terziovski, 2011). Even though food products seem to be safer than ever before, from a technical point of view and due to many quality control programs, the safety perception of consumers has decreased significantly Food products and production processes have a number of specific characteristics that influence product quality and quality assurance in production processes (Ried,2010, Van de vorst, 2000).

At the same time, food sectors have rapidly internationalized. Market demand is no longer confined to local or regional supply. These factor transforming the food industry towards an interconnected system with a large variety of complex relationships. To deal with these challenges, companies around the world are increasingly using standard quality assurance systems to improve the quality and safety of food products and production processes. Quality assurance systems enable the application and verification of control measures intended to assure the quality and safety of food. They are required at each step in the food production chain to ensure safe food and to show compliance with regulatory and customer requirements. Governments have an important role in providing policy guidance on the most appropriate quality assurance systems and verifying/auditing their implementation as a mean of regulatory (FAO, 2002).

Quality and safety characteristics of food production

Food products and production processes have a number of specific characteristics that influence product quality and quality assurance in production processes (Vorst van der, 2000).

.

1) Quality variation between different producers and between different lots of produce, due to, e.g., weather conditions, biological variation and seasonality, but also as a possible result of variations in production.

2) Perishability of produce and fresh products. For many materials shelf-life constraints apply.

3) Production yields are often uncertain due to, for example, weather conditions and quality variation within and between lots.

4) There are special demands for storage and transportation, such as cooling facilities and hygienic measurements.

Since the 1990s many private food quality and safety standards have been developed. The major aims of private food safety standards are . Instrument innovation in agriculture is a system analysis of the instruments that support innovation in agriculture was carried out .Market strategy is another process to be analyzed .Academic discussion of farmers 'markets has tended to focus on the socialization and economization of markets, such as the role of markets in the lives of older consumers (Szmigin et al., 2003) and in building networks of local producers and consumers (Holloway et al., 2007), and in the generation of new businesses . Food market is a place where local growers, farmers and artisan food producers sell their wares directly to customers. Marketing performance is a multidimensional construct (Sampiao *et al.*, 2011,Neely,2005). It is composed of effectiveness, efficiency and adaptability (Morgan *et al.*, 2002). Marketing performance concerns market place awareness and reactions to the realized positional advantage. Marketing performance can be defined from three different perspectives; customer, competitor and internal perspectives (Vorlaufer et al,2012,Ulaga,2002). Rust *et al.*, (2004a), describes marketing performance as consists of sequentially of customer impact, market impact, financial impact and impact on firm value. food market is a place where local growers, farmers and artisan food producers sell their wares directly to customers. Vendors may only sell what they grow, farm, pickle, preserve, bake, smoke or catch themselves from within a defined local area. The market takes place at a public location on a regular basis (FMNZ, 2010; Hall et al., 2008). Vendors may only sell what they grow, farm, pickle, preserve, bake, smoke or catch themselves from within a defined local area.).For this proper linking between farmer and market is need. Behaviour issues affects farming process in effective ways. The optimization of the transport system of AFSCs has been addressed by many researchers. Higgins et al. (2006) proposed a model framework to improve the efficiency of both the harvesting and transport operation. Boudahri,Bennekrouf, and Sari (2011) proposed a model for the design and optimization of the transportation network of an AFSC .In the context of the ASC, we have identified four main functional areas: production, harvest, storage, and supplier During the supplier selection process, many factors need to be analyzed. Strategic long-term relationships and integration with suppliers is one of the key aspects in managing SCs, including choice of the right suppliers (Prajogo *et al.*, 2012). bution Theocharopoulos et al. (2012) examine the factors affecting the decision of farmers to adopt or not to adopt organic farming and integrated crop management in food sector. technical and economic reasons and the shortage of scientific support networks are factors affecting the decision; subsidies do not seem to play an important role in the decision to convert to integrated crop management, but these factor affect the decision to adopt organic farming, less so than environmental and ideological aspects. Bravo et al. (2012) address farmers' satisfaction with organic certification and its determinants. Organic farming is a form of agriculture that relies on techniques such as crop rotation, green manure compost and biological pest control. Depending on definition , organic farming uses fertilizers and pesticides (which include herbicides, insecticides and fungicides) if they are considered natural(such as bone meal from animals or pyrethrin from flowers), but it excludes or strictly limits the use of various methods (including synthetic petrochemical fertilizers and pesticides; plant growth regulators such as hormones; antibiotic use in livestock; genetically modified organisms;(Paul,2011). Farmers markets have been growing in number and popularity, providing valuable opportunities for thousands of full- and part-time farmers (Kremen,et al 2004). Various reasons for their continued growth have been advanced in the literature (Fitzgerald 2004) ranging from health conscious consumers purchasing more fresh fruits and vegetables (Hughes and Mattson 1992) to food safety concerns about foods brought in from distant parts of the country or from overseas So consumer should be aware of farming process and food quality.

4.2.3 Performance: The performance of a supply chain can be defined by supply chain profitability, which has only one source of income: the customer (Chopra and Meindl, 2001). According to Vander Vorst (2000) supply chain performance is the degree to which a supply chain fulfils end user requirements concerning the relevant performance indicators at any point in time regarding total supply chain cost. According to Neely et al. (2005) performance measurement is the process of quantifying the efficiency and effectiveness of all the action involved in supply chain. Lambert and Pohlen (2001) summarized the major issues in checking reliability of food supply chains as follows:

1. The lack of measures that analyze performance across the entire supply chain i,e path tracker for food product, decoding of bar coder.

2. The requirement to go beyond internal firm measures and to go to food supply chain perspective i,e farmer condition,releation between member.

3. The requirement to align activities and share joint performance measurement information to implement strategy that achieves supply chain objectives i,e proper interlinking between quality department and manufacturing department.

Product quality and safety is key factor for performance measurement. In the last decades, a wide range of food scares was reported throughout the country(Knowles et al., 2007). Food safety risks stemming from production may be caused by technological hazards, i.e. a genuine lack of knowledge about the stochastic effects of complex production systems or by technical failures. Food safety risks may also be caused by moral hazard, i.e. by deviant economic behavior (Friedrichs, 2010;) of self-interested actors who intentionally break contractual and/or legal rules such as those aimed at protecting consumers' health. Price spreads for different quality categories and/or the costs of compliance with public and/or private quality and safety standards may tempt self-interested producers to exploit consumers' lack of information. The probability that quality and safety threats or other undesired production outcomes are caused by malpractice rises in line with the profits that can be earned from opportunistic acts .Hennessy et al. (2003) as well as Unnevehr and Jensen (2005) proposed that misdirected incentives are a major source of food risks and that there are relevant constellations in food supply chains where non-transparent markets and ill-enforced rules make non-compliance more profitable than compliance .The food system is essential to health for the obvious reason that we depend on a safe and adequate food supply to survive. Globally, agriculture—the production of food and goods through growing crops and raising animals—provides the vast majority of the raw foods and ingredients that form the basis of our food supply (pimental,2006). Food processing—the practices used to transform raw plant and animal materials into products for consumers (heldmen,1997)can extend the availability of certain foods and reduce the risk of food borne illness. Food holds many meanings and serves many roles. At its most basic level, it is a source of nourishment, without which we would cease to function. On a global scale, nations depend on food for political stability. Among the one in six people worldwide lack adequate access to food (FAO,2011) .So food should available in adequate amount and better quality due to the complexity pertaining to the relationship between the health and taste attributes of food and interactive effects of product type and consumer factors, some managerial actions can backfire and lead to unintended effects. For example, the "tastiness" label increased the flavor intensity perception for the Comet cheese, but not for the Emmental cheese and this effect was dependent on consumers' age (Jacquot et al., 2013)

Responsive is parameter for performance measurement. Responsiveness aims at providing the requested products with a short lead time.. Responsiveness is found to be related to market performance (Han et al. 1998; Homburg et al. 2007;

Hult et al. 2005), new product success (Han et al. 1998), and adaptive capacity (Benner 2009; Zhou and. Li 2010).It may include fill rate, product lateness, customer response time, lead time, shipping errors, and customer complaints. The specific characteristics of agri-food supply chains are captured in the measurement framework .Food product lateness can be define in term of lead time. defined manufacturing lead time as the difference between when an order is released to the shop and when it is available to the customer. Responsiveness can be improved by telecommunication and digital request. Responsiveness improves customer service. Customer service and quality of service are not easy factors to define precisely. In practice, customer service elements can be used to measure, the process of servicing the customers (Christopher, 1998). In other words, an

Identification of the elements of customer service provides a basis for measuring customer service (Collins et al., 2001).Any service comprises a mixture of some physical items which form part of the service and the interaction of the service organization with the customer characteristically through a personal face to face interaction. This mixture makes the service package, food and drink in a restaurant' .Also many services organizations offer not one but a number of services in a service bundle. elements of customer service grouped into pre transaction, transaction and post transaction elements(Chen et al,2000). On time delivery of food product (fast food) to customer can be achieved by Remote Encounters - occurs without direct human contact such as when a customer interacts with the bank through the ATM system, with Ticket on through an automated ticketing machine, with the retailer through its Internet website. Although there is no direct human contact in these remote encounters, each represents an opportunity for the firm to reinforce or establish quality perceptions in the customer.

Table 4.1: Factors taken for selecting supply chain

Factor	Sub-factors	Refrences
1. Assets(AST)	1.IT application • Material tracking • Internet • Bar coding of product	(,Nikkila,2010,Sorensen,2010, FAO,2004,Stancu,2012)
	2.Logistic and warehousing • Cold storage • Material handling • Packaging	(Yu wang & Liang 2012,,Zu,,2009,Glen&Tipper 2011,Mason et al,2011)
	3. Education and training • Training of farmers • Awareness program • Trade fair for gathering information	(Bertolini ,etal,2007,Nakabagu 2011,Nazimi and Hasbullah,2010 FAO 2001,)
	4.R&D • Awareness of new technology(developin	,(Yeoh et al ,1995,IFAD,2011,Aubert 2012,Schmid & Schiender,2011)

	g of new technology of farming) • Improving Scientific tempor for cultivation(hybrid crop)	
2 . Processes(PRO)	1. market strategy • Vendor development • Market analysis	(Sampio,2011,Szmigin et al ,2003,Holloway et al,2007,Vorlaufer,2012,Rust 2004)
	2. Quality control • ISO standard for food products • Food safety • Quality standard • Agriculture instrument innovation	(FAO,2002,Ried,2010,, van der vorst ,2000,Teziovski,2011,FMNZ 2010)
	3. Network optimization • Alternative supply network • Alternative vendor • Alternative supplier • Proper linking of farmer and market	(Boudhari et al 2011,Higgins 2006,Prajago et al 2007)
	4.Behavioural issue • Motivate farmer for organic farming • Behaviour of Customer toward farming • Attitude of retailer	(Theocharopoulos et al,2012 , Bravo et al 2012,Paul,2011,Fitzgerald,2004,)

	towards the farmer	
3.Performance(PERF)	1.Product quality • Product safety and health • Product reliability • Product taste	(Friedrichs,2010,Knowles 2007 Hensy 2003,Jacquot et al 2013)
	2 .Responsiveness • Product lateness • Customer response time • Customer complaints	(Homburg et al 2007,Benner 2009 Zhou and Liang 2010,Halt et al 2005)
	3 .Customer service • On time delivery • Response to customer • Speed of delivery	(Chen et al 2000,Collins 2001,Christopher 1998)

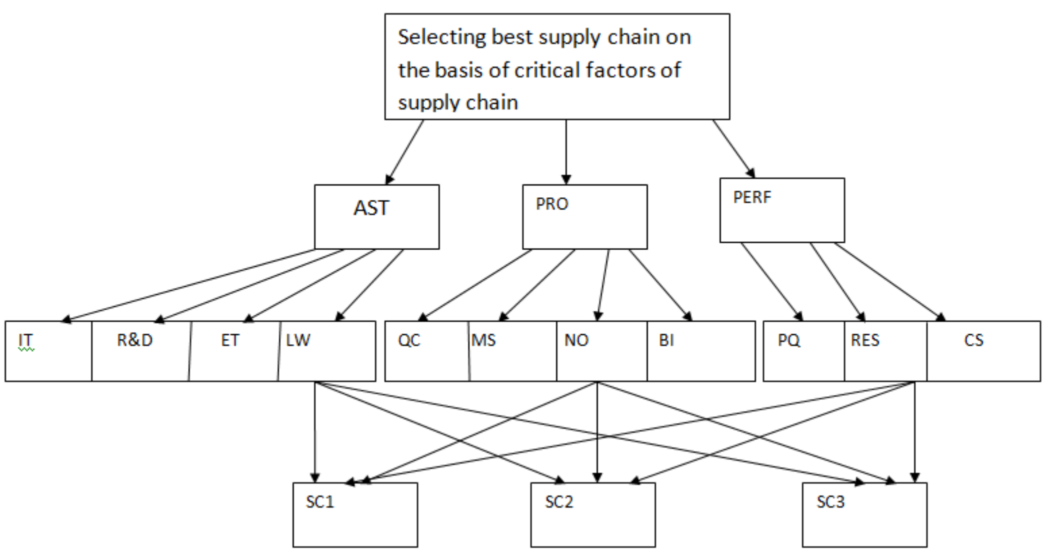

Fig 4.1: Hierarchy model for selecting food supply chain

4.3 Case illustration

In order to demonstrate the use of fuzzy AHP and extent analysis, an industrial case has been discussed. The supply chain of three pharmaceutical firms have been identified and compared on the basis of the identified factors using the same method

4.3.1 ABC Ltd (Reliance Food Corporation)

ABC is a company to invest in excess of 250 billion in the next 4 years in their retail division. The company already has 1691 Fresh outlets across the country. These stores sell fresh fruits and vegetables, staples, groceries, fresh juice, bars and dairy products. A typical Fresh store is approximately 3000–4000 square feet and caters to a catchment area of 2–3 km After launch, in a dramatic shift in its positioning and mainly due to the circumstances prevailing in UP, West Bengal and Orissa, it was mentioned recently in news dailies that Retail is moving out of stocking fruits and vegetables. It has decided to minimize its exposure in the fruit and vegetable business. When the first Fresh store opened in Hyderabad last October, not only did the company say the store's main focus would be fresh produce like fruits and vegetables at a much lower price, but also spoke at length about its "farm-to-fork" theory. The idea the company spoke about was to source from farmers and sell directly to the consumer, removing middlemen out of the way. ABC company has two plants in Gurgaon and Faridabad spread over 500 acres and 200 vendor and supplier. The R&D of this company is carried out by American company Ltd. ABC received 9001 standard for food quality and safety. ABC has production capacity 3000 type of packed food material.

4.3.2 GHI Ltd (Vishal megamart food supply chain)

GHI is an Indian food company. Founded in October 1984. It is an nutritionally balanced breakfast and began experimenting with different whole grains and seeds. Specializes in breakfast cereals; energy bars; crackers; frozen entrées including pizza and breakfast foods; as well as snack foods. The company advertises their products as a blend of seven whole grains and sesame and emphasizes high protein and fiber content. It has two manufacturing plants in Gujarat and Hyderabad spread over 300 acres. It has very good fast food service record using telecommunication and internet. It has acquired 22000 standards for food safety.

4.3.3 XYZ Ltd (American Food Company)

Another xyz is an operates a chain of discount department stores and warehouse stores. Headquartered in Bentonvil, Arkansas, United States, the company was founded in 1962 and in corporate on October 31, 1969. It has over 11,000 stores in 28 countries, under a total 65 banners. It is the world's largest company by revenue, according to the Fortune Global 500 list in 2014, as well as the biggest private employer in the world with 2.2 million employees. It is also one of the world's most valuable companies by market value, and is also the largest grocery retailer in the U.S. In 2009, it generated 51 percent of its US$258 billion (equivalent to $284 billion in 2015) sales in the U.S. from its grocery business. This XYZ has certified with 14001 standard for environment safety

4.4 Research Methodology AHP introduced by Satty (1980) is a quantitative technique that structures a multi-criteria, multi person, multi period problem hierarchically so that solutions are facilitated. The application of

Satty's AHP has some limitation as follows:

(1) The AHP method mainly used in nearly crisp decision application.
(2) The AHP methods create and deal with the very unbalanced scale of judgment.
(3) The AHP method cannot handle the uncertainty and ambiguity associated with mapping of one's judgment to a number.
(4) Ranking of AHP method is rather imprecise.

(5) The subjective judgment, selection and preference of decision makers have great

Influence on the AHP results. Therefore Fuzzy AHP methodology Extends Satty's AHP by combining it with fuzzy set theory to solve hierarchical fuzzy problems. The fuzzy AHP method offer the number of benefits like, it can capture uncertain imprecise judgment of experts by handling linguistic variables. It is not completely captured the importance of qualitative aspects because its discrete scale couldn't reflect the human thinking style. Recently fuzzy AHP is widely used to solve multi-criteria decision problems in few other areas e.g. selection of thermal power plant by Choudhary and Shankar (2012), strategic analysis of electronic service quality by Buyukozkan (2012), renewable energy planning by Kaya and Kahraman (2010)

Step 1: According to Chang's method (1996), for each level of the constructed hierarchy, the pair-wise

Linguistic judgments are converted in TFNs and organized in fuzzy comparison matrices as follows:

$$\tilde{D} = (\tilde{d}_{ij})_{n\times m} = \begin{pmatrix} (1, 1, 1) & \ldots & (X_{12}, Y_{12}, Z_{12}) & \ldots & (X_{1n}, Y_{1n}, Z_{1n}) \\ (X_{21}, Y_{21}, Z_{21}) & \ldots & (1, 1, 1) & \ldots & (X_{2n}, Y_{2n}, Z_{2n}). \\ X_{n1}, Y_{n1}, Z_{n1}) & \ldots & (X_{n2}, Y_{n2}, Z_{n2}) & & (1,1,1) \end{pmatrix}$$

Where

$$\tilde{d}_{ij} = (X_{ij}, Y_{ij}, Z_{ij}) \qquad \ldots\ldots. (1)$$

$\tilde{d}_{ji}{-1} = \left(\frac{1}{Z_{ji}}, \frac{1}{Y_{ji}}, \frac{1}{X_{ji}} \right)$ i, j = 1,2,……………n; $i \neq j$ …….. (2)

Represent the linguistic judgment for the items i and j; thus D̃ is a square and symmetrical matrix.

Table 4.2: Triangular fuzzy conversion scale (chang, 1996; Lee, 2010)

Linguistic Scale	Triangular Fuzzy Conversation scale	Triangular Fuzzy reciprocal scale
Absolutely important	(3.5,4,4.5)	(3.5,4,4.5)
Strongly important	(2.5,3,3.5)	(2.5,3,3.5)
Fairly important	(1.5,2,2.5)	(1.5,2,2.5)
Weakly important	(.667,1,1.5)	(.667,1,1.5)
Equally important	(1,1,1)	(1,1,1)

Step 2: Yager (1981) gives centroid defuzzification method which is also called center of gravity. This method converts the fuzzy comparison matrices into crisp comparison matrices. In case of triangular fuzzy number the translating formula is given by Wang and Elhag (2007). The translating formula is:

$d_{ij}(\tilde{d}_{ij}) = \frac{X_{ij} + Y_{ij} + Z_{ij}}{3}$ ………. (3)

Where

$\tilde{d}_{ij} = (X_{ij}, Y_{ij}, Z_{ij})$

Step 3: calculate the consistency of each comparison matrix by calculating the consistency index (CI) and also calculate consistency ratio (CR)

CI = $\frac{(\lambda_{max} - n)}{n-1}$ ………. (4)

CR = $(CI / RI(n))100\%$ ………. (5)

Where largest Eigen value of the comparison matrix is λ_{max} and dimension of matrix is n and random index is RI(n). Random index is depend upon the value of n which is shown in table 5.4.

Table4.3: RI of random matrices

N	3	4	5	6	7	8	9
RI(n)	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Source: Golden, Harker and Wasil, 1989.

The consistency of the matrix is acceptable only if CR is less than 10%. Nevertheless, the threshold of 10% can be increased or decreased depending on the tolerance of the decision makers. If a matrix gives result inconsistent then it is necessary to obtain new pair-wise comparison judgments. Then determining a new pair-wise fuzzy comparison matrix to analyze. The matrix review must be continuing until the consistency is obtained.

Step 4: we calculate the relative sum of each row of D̃ as:

$\tilde{RS} = \sum_{j=1}^{n} d_{ij} = \sum_{j=1}^{n} X_{ij}, \sum_{j=1}^{n} Y_{ij}, \sum_{j=1}^{n} Z_{ij}$ i = 1,2,…….,n ……… (6)

Step 5: According to Wang and Elhag's (2006), we normalized the row sum ($\tilde{S}_i$) as:

$$\tilde{S}_i = \frac{RS_i}{\sum_{j=1}^{n} RS_j}$$

$$= \frac{\sum_{j=1}^{n} X_{ij}}{\sum_{j=1}^{n} X_{ij} + \sum_{k=1,k\neq i}^{n} \sum_{j=1}^{n} Z_{kj}}, \frac{\sum_{j=1}^{n} Y_{ij}}{\sum_{k=1,k\neq 1}^{n} \sum_{j=1}^{n} Y_{kj}}, \frac{\sum_{j=1}^{n} Z_{ij}}{\sum_{j=1}^{n} Z_{ij} + \sum_{k=1,k\neq i}^{n} \sum_{j=1}^{n} X_{kj}} \quad \text{……….. (7)}$$

Step 6: calculate the local priority weight of each criterion and sub criterion.

$$A_i = S(\tilde{S}_i) = \frac{X_i + Y_i + Z_i}{3} \quad \text{………. (8)}$$

Where

$\tilde{S}_i = (X_{ij}, Y_{ij}, Z_{ij})$

Table 4.4: Abbreviation

AST=ASSETS	IT= IT Infrastructure LW=Logistic and warehousing R&D=Research and development ET=Education and training
PRO=PROCESSES	QC=Quality control NO=Network optimization MS=Market strategy BI=Behaviour issues
PERF=PERFORMANCE	PQ= Product Quality RES=Responsiveness CS=Customer satisfaction
R1=Row sum matrix	W=Normalized weight matrix
Mi=Mean weightage	Ni=Normalized weightage
APW=Alternative priority weight	RP=Reciprocal, IO=Increasing order

4.5 Findings and discussion

Results are shown in Table 4.5 is fuzzy evaluation matrix with respect to goal of asset, process and performance. After that row sum matrix table 4.6 calculated by taking geometric mean of table 4.5. After that we normalized the matrix. Table 4.7 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.8. In this table process has highest weight, then performance finally asset has lowest weight. So for success of food supply chain process need to be improved firstly. Result are shown in Table 4.9 is fuzzy evaluation matrix with respect to asset .After that row sum matrix table 4.10 calculated by taking geometric mean of table 4.9. After that we normalized the matrix. Table 4.11 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.12 .In this table information and technology has highest weight ,then education and training, research and developement,logistic and warehousing has lowest weight .So IT need to be improved for supply chain success. Result is shown in Table 4.13 is fuzzy evaluation matrix with respect to process .After that row sum matrix table 4.14 calculated by taking geometric mean of table 4.13. After that we normalized the matrix. Table 4.15 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.16.In this table quality control has highest weight, then market and strategy, network optimization, behaviour issues has lowest weight. So for improving process, quality control needs to be improved. Result are shown in Table 4.17 is fuzzy evaluation matrix with respect to performance .After that row sum matrix table 4.18 calculated by taking geometric mean of table 4.17. After that we normalized the matrix. Table 4.19 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.20.In this table responsiveness has highest weight, and then product quality, customer service has lowest weight. So supply chain need to be responsive for better product quality which improve customer satisfaction. Result shown in Table 4.21 is fuzzy evaluation matrix with respect to Information technology. After that row sum matrix table 4.22 calculated by taking geometric mean of table 4.21. After that we normalized the matrix. Table 4.23 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.24.In this table SC3 has highest weight. So SC3 is selected for IT. Result shown Table 4.25 is fuzzy evaluation matrix with respect to Research and developement.After that row sum matrix table 4.26 calculated. After that we normalized the matrix. Table 4.27 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.28.In this table SC1 has highest weight. So SC3 is selected for R&D.Result shown Table 4.29 is fuzzy evaluation matrix with respect to logistic and warehousing. After that row sum matrix table 4.30 calculated. After that we normalized the matrix. Table 4.31 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.32.In this table SC3 has highest weight. So SC1 is selected for LW.

Result shown Table 4.33 is fuzzy evaluation matrix with respect to goal of Education and training. After that row sum matrix table 4.34 calculated. After that we normalized the matrix. Table 4.35 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.36.In this table SC2 has highest weight. So SC2 is selected for ET.Result shown Table 4.37 is fuzzy evaluation matrix with respect to Quality control. After that row sum matrix table 4.38 calculated. After that we normalized the matrix. Table 4.39 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.40 .In this table SC1 has highest weight.So SC1 is selected for QC.Result shown Table 4.41 is fuzzy evaluation matrix with respect to Network optimzation.After that row sum matrix table 4.42 calculated. After that we normalized the matrix. Table 4.43 shows normalized weighted matrix.Finally the individual weight calculated from weighted normalized weight table 4.44.In this table SC2 has highest weight’s SC2 is selected for NO. Result shown Table 4.45 is fuzzy evaluation matrix with respect to Market strategy. After that row sum matrix table 4.46 calculated. After that we normalized the matrix. Table 4.47 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.48 Table. In this table SC3 has highest weight. So SC3 is selected for MS.Result shown 4.49 is fuzzy evaluation matrix with respect to Behaviour issues. After that row sum matrix table 4.50 calculated. After that we normalized the matrix. Table 4.51 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.52.In this table SC2 has highest weight. So SC2 is selected for BI.Result shown Table 4.53 is fuzzy evaluation matrix with respect to product quality. After that row sum matrix table 4.54 calculated. After that we normalized the matrix. Table 4.55 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.56.In this table SC3 has highest weight. So SC3 is selected for PQ.Result shown Table 4.57 is fuzzy evaluation matrix with respect to Responsiveness. After that row sum matrix table 4.58 calculated. After that we normalized the matrix. Table 4.59 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.60 .In this table SC2 has highest weight. So SC2 is selected for RES.Result shown Table 4.61 is fuzzy evaluation matrix with respect to Customer satisfaction. After that row sum matrix table 4.62 calculated. After that we normalized the matrix. Table 4.63 shows normalized weighted matrix. Finally the individual weight calculated from weighted normalized weight table 4.64.In this table SC1 has highest weight. So SC1 is selected for CS. Table 1.65 is Summary of all weight factor with respect to asset. From this table SC3 is selected for asset. Result shown Table 1.66 is Summary of all weight factors with respect to Process. From this table SC2 is selected for process. Result shown Table 1.67 is Summary of all weight factors with respect to Performance. From this table SC1 is selected for performance,. Result shown Table 1.68 is Summary of all weight factors. In this table SC1 has highest weight. So SC1 is selected for food supply chain

Table 4.5: The fuzzy evaluation matrix with respect to the goal

		AST			PRO			PERF				
	P	Q	R	P	Q	R	P	Q	R			
AST	1	1	1	0.66	1	1.5	0.4	0.5	0.667	0.2668	0.5	1.000
PRO	1.4992	2	2.5	2.4	0.4	0.5	0.66	1	1	2.39999	0.8	1.25
PERF	0.667	1	1.49	1	1	1	1.5	2	0.4	1.0005	2	0.599

Table 4.6: Row Sum Matrix

		R1	
	AST	PRO	PERF
AST	0.646608	0.795536	1.000165
PRO	1.334964	0.929009	1.076416
PERF	1.000165	1.257013	0.844684
TOTAL	2.981738	2.981558	2.921266
RP	0.335375	0.335395	0.342317
IO	0.342317	0.335395	0.335375

Table 4.7: Normalized weight matrix

		W	
AST	0.221345	0.266819	0.33543
PRO	0.456982	0.311585	0.361003
PERF	0.342374	0.421596	0.283286

Table 4.8: Weightage column matrix

	Mi	Ni
AST	0.274532	0.274493
PRO	0.376523	0.37647
PERF	0.349085	0.349036

Table 4.9: Fuzzy evaluation matrix with respect to Asset

		IT			R &D			LW			ET				
	P	Q	R	P	Q	R	P	Q	R	p	Q	r			
IT	1	1	1	1.5	2	2.5	3	3.5	4	0.66	1	1.5	3.00	7	15
R&D	0.4	0.5	0.666	1	1	1	0.66	1	1.5	1	1	1	0.26	0.5	1
LW	0.25	0.28	0.33	0.66	1	1.49	1	1	1	0.66	1	1.5	0.11	2/7	0.749
ET	0.66	1	1.49	1	1	1	0.66	1	1.49	1	1	1	0.44	1	2.24

Table 4.10: Row Sum Matrix

		R1	
IT	1.31624	1.62658	1.96799
R&D	0.7187	0.8409	1
LW	0.57742	¾	0.93049
ET	0.8165	1	1.22444
TOTAL	3.42886	4.19858	5.12292
RP	0.29164	0.23	0.1952
IO	0.1952	0.23	0.29164

Table 4.11: Normalized weight matrix

		W1	
IT	0.25693	0.37411	0.57395
R&D	0.14029	0.19341	0.29164
LW	0.11271	1/6	0.27137
ET	0.15938	0.23	0.3571

Table4.12: Weightage column matrix

	MI	NI
IT	0.40166	0.3851
R&D	0.20845	0.19985
LW	0.18408	0.17649
ET	0.24883	0.23856

Table 4.13: Evaluation of matrix with respect to process

		QC			NO			MS			BI				
	P	Q	R	P	Q	R	P	Q	r	P	q	r			
QC	1	1	1	1.5	2	2.5	1	1	1	0.66	1	1.5	1.00	2	3.75
NO	0.4	0.5	0.66	1	1	1	0.66	1	1.5	1.5	2	2.5	0.40	1	2.5
MS	1	1	1	0.66	1	1.4	1	1	1	1.5	2	2.5	1	2	3.74
BI	0.666	1	1.49	0.4	0.5	0.6	0.4	0.5	0.66	1	1	1	0.106	0.25	0.66

Table4.14: Row Sum Matrix

		R1	
QC	1.00012	1.18921	1.39158
NO	0.79537	1	1.25743
MS	1	1 1/5	1.3914
BI	0.57149	0.70711	0.90349
TOTAL	3.36698	4.08552	4.94391
RP	0.297	0.23	0.20227
IO	0.20227	0.23	0.297

Table 4.15: Normalized weight matrix

		W1	
QC	0.20229	0.27352	0.4133
NO	0.16088	0.23	0.37346
MS	0.20227	2/7	0.41325
BI	0.11559	0.16263	0.26834

Table4.16: Weightage column matrix

	MI	NI
QC	0.29637	0.28783
NO	0.25478	0.24743
MS	0.29635	0.2878
BI	0.18219	0.17694

Table4.17: Fuzzy evaluation matrix with respect to Performance

		PQ			RES			CS				
	P	Q	R	P	Q	R	P	Q	R			
PQ	1	1	1	0.66	1	1.5	0.667	1	1.5	0.44	1	2.25
RES	0.66	1	1.49	1	1	1	1.5	2	2.5	1	2	3.748
CS	0.66	1	1.49	0.4	0.5	0.666	1	1	1	0.26	0.5	0.99

Table4.18: Row Sum Matrix

		R1	
PQ	0.765461	1	1.306833
RES	1	1.257013	1.546531
CS	0.646502	0.795536	0.999835
TOTAL	2.411963	3.05255	3.8532
RP	0.4146	0.327595	0.259525
IO	0.259525	0.327595	0.4146

Table4.19: Normalized weight matrix

		W	
PQ	0.198656	0.327595	0.541813
RES	0.259525	0.411791	0.641192
CS	0.167783	0.260614	0.414532

Table4.20: Weightage column matrix

	Mi	Ni
PQ	0.356021	0.331337
RES	0.437503	0.407168
CS	0.280976	0.261495

Table4.21: Evaluation of supply chain with respect to Information technology

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	0.66	1	1.5	0.4	0.5	0.66	0.266	0.5	1.00
SC2	0.66	1	1.49	1	1	1	0.66	1	1.5	0.44	1	2.248
SC3	1.49	2	2.5	0.66	1	1.49	1	1	1	0.99	2	3.74

Table 4.22: Row Sum Matrix

		R1	
SC1	0.646608	0.795536	1.000165
SC2	0.765335	1	1.306618
SC3	0.999835	1.257013	1.546531
TOTAL	2.411778	3.05255	3.853314
RP	0.414632	0.327595	0.259517
IO	0.259517	0.327595	0.414632

Table4.23: Normalized weight matrix

		W	
SC1	0.167806	0.260614	0.4147
SC2	0.198617	0.327595	0.541765
SC3	0.259474	0.411791	0.641241

Table4.24: Weightage column matrix

	Mi	Ni
SC1	0.28104	0.261546
SC2	0.355993	0.331299
SC3	0.437502	0.407155

Table4.25: Evaluation of supply chain with respect to Research and development

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	1.5	2	2.5	0.4	0.5	0.66	0.6	1	1.66
SC2	0.4	0.5	0.66	1	1	1	0.66	1	1.5	0.26	0.5	1
SC3	1.49	2	2.5	0.66	1	1.49	1	1	1	0.99	2	3.74

Table4.26: Row Sum Matrix

		R1	
SC1	0.84487	1	1.183809
SC2	0.646608	0.795536	1
SC3	0.999835	1.257013	1.546531
TOTAL	2.491313	3.05255	3.73034
RP	0.401395	0.327595	0.268072
IO	0.268072	0.327595	0.401395

Table4.27: Normalized weight matrix

		W	
SC1	0.226486	0.327595	0.475175
SC2	0.173338	0.260614	0.401395
SC3	0.268028	0.411791	0.620769

Table4.28: Weightage column matrix

	Mi	Ni
SC1	0.343085	0.32518
SC2	0.278449	0.263917
SC3	0.43353	0.410904

Table4.29: Evaluation of fuzzy matrix with respect to Logistic and warehousing

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	1.5	2	2.5	0.4	0.5	0.66	0.6	1	1.66
SC2	0.4	0.5	0.66	1	1	1	0.66	1	1.5	1.5	2	2.5
SC3	1.49	2	2.5	0.66	1	1.49	1	1	1	0.99	2	3.74

Table4.30: Row Sum Matrix

		R1	
SC1	0.84487	1	1.183809
SC2	1.143168	1.257013	1.35307
SC3	0.999835	1.257013	1.546531
TOTAL	2.987873	3.514027	4.08341
RP	0.334686	0.284574	0.244893
IO	0.244893	0.284574	0.334686

Table4.31: Normalized weight matrix

		W	
SC1	0.206903	0.284574	0.396205
SC2	0.279954	0.357713	0.452854
SC3	0.244853	0.357713	0.517603

Table4.32: Weightage column matrix

	Mi	Ni
SC1	0.295894	0.286499
SC2	0.363507	0.351966
SC3	0.37339	0.361535

Table4.33: Evaluation of fuzzy matrix with respect to education and training

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	0.4	0.5	0.66	1.5	2	2.5	0.6	1	1.66
SC2	1.49	2	2.5	1	1	1	0.66	1	1.5	1	2	3.75
SC3	0.4	0.5	0.666	0.66	1	1.49	1	1	1	0.26	0.5	0.99

Table4.34: Row Sum Matrix

		R1	
SC1	0.84487	1	1.183809
SC2	1	1.257013	1.546786
SC3	0.646502	0.795536	0.999835
TOTAL	2.491372	3.05255	3.730431
RP	0.401385	0.327595	0.268066
IO	0.268066	0.327595	0.401385

Table4.35: Normalized weight matrix

		W	
SC1	0.226481	0.327595	0.475164
SC2	0.268066	0.411791	0.620857
SC3	0.173305	0.260614	0.401319

Table4.36: Weightage column matrix

	Mi	Ni
SC1	0.34308	0.325174
SC2	0.433571	0.410943
SC3	0.278413	0.263882

Table4.37: Evaluation of fuzzy matrix with respect to quality control

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	2.5	3	3.5	0.4	0.5	0.667	1	1.5	2.33
SC2	0.285	0.333	0.4	1	1	1	1.5	2	2.5	0.42	0.66	1
SC3	1.49	2	2.5	0.4	0.5	0.66	1	1	1	0.59	1	1.66

Table4.38: Row Sum Matrix

		R1	
SC1	1	1.143168	1.32283
SC2	0.75608	0.874762	1
SC3	0.844731	1	1.183614
TOTAL	2.600811	3.01793	3.506444
RP	0.384496	0.331353	0.285189
IO	0.285189	0.331353	0.384496

Table4.39: Normalized weight matrix

		W	
SC1	0.285189	0.378792	0.508622
SC2	0.215626	0.289855	0.384496
SC3	0.240908	0.331353	0.455094

Table4.40: Weightage column matrix

	Mi	Ni
SC1	0.390868	0.379491
SC2	0.296659	0.288024
SC3	0.342452	0.332484

Table4.41: Evaluation of fuzzy matrix with respect to network optimization

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	0.4	0.5	0.66	1.5	2	2.5	0.6	1	1.66
SC2	1.49	2	2.5	1	1	1	0.667	1	1.5	1	2	3.75
SC3	0.4	0.5	0.666	0.666	1	1.49	1	1	1	0.26	0.5	0.99

Table4.42: Row Sum Matrix

		R1	
SC1	0.84487	1	1.183809
SC2	1	1.257013	1.546786
SC3	0.646502	0.795536	0.999835
TOTAL	2.491372	3.05255	3.730431
RP	0.401385	0.327595	0.268066
IO	0.268066	0.327595	0.401385

Table4.43: Normalized weight matrix

		W	
SC1	0.226481	0.327595	0.475164
SC2	0.268066	0.411791	0.620857
SC3	0.173305	0.260614	0.401319

Table4.44: Weightage column matrix

	Mi	Ni
SC1	0.34308	0.325174
SC2	0.433571	0.410943
SC3	0.278413	0.263882

Table4.45: Evaluation of fuzzy matrix with respect to market strategy

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	0.667	1	1.5	0.4	0.5	0.66	0.266	0.5	1.00
SC2	0.666	1	1.49	1	1	1	1.5	2	2.5	1	2	3.74
SC3	1.499	2	2.5	0.4	0.5	0.66	1	1	1	0.59	1	1.66

Table4.46: Row Sum Matrix

		R1	
SC1	0.646608	0.795536	1.000165
SC2	1	1.257013	1.546531
SC3	0.844731	1	1.183614
TOTAL	2.491339	3.05255	3.73031
RP	0.401391	0.327595	0.268074
IO	0.268074	0.327595	0.401391

Table4.47: Normalized weight matrix

		W	
SC1	0.173339	0.260614	0.401457
SC2	0.268074	0.411791	0.620763
SC3	0.226451	0.327595	0.475091

Table4.48: Weightage column matrix

	Mi	Ni
SC1	0.27847	0.263938
SC2	0.433543	0.410918
SC3	0.343046	0.325144

Table4.49: Evaluation of matrix with respect to behaviour issues

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	0.4	0.5	0.667	0.4	0.5	0.66	0.16	0.25	0.44
SC2	1.49	2	2.5	1	1	1	0.66	1	1.5	1	2	3.75
SC3	1.49	2	2.5	0.66	1	1.49	1	1	1	0.99	2	3.74

Table4.50: Row Sum Matrix

		R1	
SC1	0.54621	0.632878	0.765461
SC2	1	1.257013	1.546786
SC3	0.999835	1.257013	1.546531
TOTAL	2.546045	3.146905	3.858778
RP	0.392766	0.317773	0.259149
IO	0.259149	0.317773	0.392766

Table4.51: Normalized weight matrix

		W	
SC1	0.14155	0.201111	0.300647
SC2	0.259149	0.399444	0.607525
SC3	0.259107	0.399444	0.607425

Table4.52: Weightage column matrix

	Mi	Ni
SC1	0.214436	0.202591
SC2	0.42204	0.398727
SC3	0.421992	0.398682

Table4.53: Evaluation of matrix with respect to product quality

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	2.5	3	3.5	0.4	0.5	0.667	1	1.5	2.33
SC2	0.28	0.33	0.4	1	1	1	0.66	1	1.5	0.19	0.333	0.6
SC3	1.49	2	2.5	0.66	1	1.49	1	1	1	0.99	2	3.74

Table4.54: Row Sum Matrix

		R1	
SC1	1	1.143168	1.32283
SC2	0.578654	0.695905	0.84487
SC3	0.999835	1.257013	1.546531
TOTAL	2.578489	3.096087	3.714231
RP	0.387824	0.322988	0.269235
IO	0.269235	0.322988	0.387824

Table4.55: Normalized weight matrix

		W	
SC1	0.269235	0.36923	0.513025
SC2	0.155794	0.224769	0.327661
SC3	0.26919	0.406001	0.599782

Table4.56: Weightage column matrix

	Mi	Ni
SC1	0.38383	0.367338
SC2	0.236075	0.225931
SC3	0.424991	0.406731

Table4.57: Evaluation of matrix with respect to Responsiveness

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	0.4	0.5	0.66	1.5	2	2.5	0.6	1	1.66
SC2	1.49	2	2.5	1	1	1	0.66	1	1.5	1	2	3.75
SC3	0.4	0.5	0.66	0.66	1	1.49	1	1	1	0.26	0.5	0.99

Table4.58: Row Sum Matrix

		R1	
SC1	0.84487	1	1.183809
SC2	1	1.257013	1.546786
SC3	0.646502	0.795536	0.999835
TOTAL	2.491372	3.05255	3.730431
RP	0.401385	0.327595	0.268066
IO	0.268066	0.327595	0.401385

Table4.59: Normalized weight matrix

		W	
SC1	0.226481	0.327595	0.475164
SC2	0.268066	0.411791	0.620857
SC3	0.173305	0.260614	0.401319

Table4.60: Weightage column matrix

	Mi	Ni
SC1	0.34308	0.325174
SC2	0.433571	0.410943
SC3	0.278413	0.263882

Table4.61: Evaluation of matrix with respect to customer service

		sc1			sc2			sc3				
	P	Q	R	P	Q	R	P	Q	R			
SC1	1	1	1	2.5	3	3.5	3.5	4	4.5	8.75	12	15.75
SC2	0.28	0.33	0.4	1	1	1	0.66	1	1.5	0.19	0.33	0.6
SC3	0.22	0.25	0.285	0.66	1	1.49	1	1	1	0.14	0.25	0.42

Table4.62: Row Sum Matrix

		RI	
SC1	2.045798	2.270543	2.48372
SC2	0.578654	0.695905	0.84487
SC3	0.532512	0.632878	0.755955
TOTAL	3.156964	3.599327	4.084545
RP	0.31676	0.27783	0.244825
IO	0.244825	0.27783	0.31676

Table4.63: Normalized weight matrix

		W	
SC1	0.500863	0.630824	0.786743
SC2	0.141669	0.193343	0.267621
SC3	0.130373	0.175832	0.239456

Table4.64: Weightage column matrix

	Mi	Ni
SC1	0.639477	0.625563
SC2	0.200878	0.196507
SC3	0.181887	0.17793

Table4.65: Summary of all weight factors of assets

		IT	R&D	LW	ET			APW
WEIGHT OF ASSETS		0.385099	0.19985	0.176488	0.238564			
ALTERNATIVE								
SC1		0.261546	0.32518	0.286499	0.325174			0.293846
SC2		0.331299	0.263917	0.351966	0.410943			0.34048
SC3		0.407155	0.410904	0.361535	0.263882			0.365673

Table4.66: Summary of all weight factors of processes

			QC	NO	MS	BI	APW
PROCESSES WEIGHT			0.287827	0.247434	0.287802	0.176937	
SC1			0.379491	0.325174	0.263938	0.202591	0.301495
SC2			0.288024	0.410943	0.410918	0.398727	0.373395
SC3			0.332484	0.263882	0.325144	0.398682	0.32511

Table4.67: Summary of all weight factors of performance

				PQ	RES	CS			APW
PERFORMANCE WEIGHT				0.331337	0.407168	0.261495			
SC1				0.367338	0.325174	0.625563			0.417695
SC2				0.225931	0.410943	0.196507			0.293568
SC3				0.406731	0.263882	0.17793			0.288737

Table4.68: Summary of all weight factors of supply chains

				AST	PRO	PERF			APW
MAIN FACTOR(GLOBAL WEIGHT)				0.2744	0.3764	0.344			
	ALTERNATIVE								
	SC1			0.293846	0.301495	0.417695			0.337801
	SC2			0.34048	0.373395	0.293568			0.334961
	SC3			0.365673	0.32511	0.288737			0.322038

4.6 Conclusion

Fuzzy Ahp is used for prioritization of supplier based on various factors. For this three food supply chain taken and firms are given ranking. Fuzzy ahp uses linguistic number used which are not very accurate for decision maker but fuzzy ahp can be used in four lakh number of criteria which is not possible in fuzzy topsis.From Fuzzy ahp method we find out that organization should give more importance to process, asset and then performance .By fuzzy ahp we found out that SC1 is far more competitive than SC2 and SC

CHAPTER 5

SUMMARY AND CONCLUSIONS

In this research, it is observed that analysis of food supply chain is very important for its sustainability in global. To analyze various performance factor has been identified such as responsiveness, product quality and customer satisfaction market. Seven benefits of lean manufacturing have been discussed. Various element of food supply chain are farmer, retailer, wholesaler, supplier and customer.

In next chapter, ten critical success factors of food supply chain are identified. Ranking of these factors were done by TOPSIS approach. Quality control got highest rank .It means it is critical factor to successfully control whole supply chain. Quality control is followed education and training, environmental awareness and government policy & support, research and development, IT application, logistic and warehousing, network optimization, market strategy finally behavior issues.

The above factor can be used for selecting best supply chain .So in the next chapter all sub factor combine into three factor asset, process and performance. In this fuzzy ahp is used in which linguistic value is used. By fuzzy ahp pairwise comparison process has highest normalized weight then performance finally asset. By analysis SC1 has highest normalized weight then SC2 finally SC3.So SC1 supply chain selected for food supply

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