Food and Waste Supply Chain Management System

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LUCKNOW

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DECLARATION

We hereby declare that this submission is our own work and that, to the best of our knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree of the university or other institute of higher learning except where due acknowledgement has been made in the text.

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CERTIFICATE

This is to certify that the Project entitled " **Food and Waste Supply Chain Management System**" which is submitted by Abhishek Rajput (1900910400007), Aniket Gupta (1900910400025), Anmol Agrawal (1900910400029), Deepak Chauhan (1900910400048) in partial fulfillment of the requirement for the award of degree B. Tech in Department of Mechanical Engineering of J.S.S Academy of Technical Education, NOIDA, affiliated to Dr. A.P.J. Abdul Kalam Technical University, Lucknow is a record of the candidates own work carried out by them under my supervision. The matter embodied in this thesis is original and has not been submitted for the award of any other degree.

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ABSTRACT

The aim of this research paper is to evaluate the factors that prevent the reduction of waste in the Indian agri-food supply chain (AFSC). Minimizing food waste has positive impacts on all three dimensions of sustainability: economic, social, and environmental. Through a comprehensive review of existing literature and expert consultation within the Indian food industry and academia, 33 factors inhibiting waste reduction in AFSC were identified. These factors were then analyzed using Delphi Analysis to group them into nine broader factors.

The Inter-relationship and respective dominance among these nine factors were then determined using Interpretive Structural Modelling and MICMAC analysis. The group of independent factors, consisting of food characteristics, supply chain uncertainty, market infrastructure, and food policy and regulation, were found to have higher driving power and low dependency. These four factors require maximum attention as they constrain decisions at all three decision-making echelons (strategic, tactical, and operational) and each of the supply-chain echelons.

On the other hand, the group of dependent factors, including supply chain partnerships, operational capability, and supply chain networks, had high dependence and low driving power and were found to be resultant effects. Information technology was identified as a linkage variable, with high driving and dependence power. It acts as an enabler of dependent variables, mitigating the complexities arising from food characteristics and uncertainty.

In conclusion, identifying and analyzing the factors inhibiting the reduction of waste in the Indian agri-food supply chain is critical to promote sustainability. The study highlights the need to address the independent factors of food characteristics, supply chain uncertainty, market infrastructure, and food policy and regulation, which have a significant impact on waste reduction at all supply-chain echelons. The findings of this research also reveal the crucial role of information technology in mitigating complexities in the AFSC. By addressing these factors and promoting sustainable practices, the Indian AFSC can reduce food waste and contribute positively to economic, social, and environmental sustainability.

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LIST OF ABBREVIATIONS

AFSC: Agri-Food Supply Chain

GHG: Green house gases

FAO: Food and agricultural organization

SCM: Supply Chain Management

ISM: Interpretive Structural Modelling

SSIM: Structural Self-Intersection Matrix

FLW: Food Loss And Waste

CPFR: Collaborative Planning, Forecasting and Replenishment

ECR: EFFICIENT CONSUMER RESPONSE

SLR: Systematic Literature Review

FCCM: Food Cold Chain Management

FCCP: Food Cold Chain Performance

FSCM: Agri-Fresh Supply Chain Management

FAO: Food and Agricultural Organization

GHG: Greenhouse Gases

ETE: Estimating, Talking About, And Estimating

CCM: Food Cold Chain Management

FCC: Food Cold Chain

CHAPTER 1
INTRODUCTION

1.1 Introduction

Supply chain management is a crucial aspect of modern business operations. It involves managing the flow of goods and services from the point of origin to the final destination. The concept of supply chain management was first introduced in the early 1980s, and it has since gained significant attention in the business world. While most studies have focused on manufactured products and services, the agri-food industry, which is a significant part of any economy, has also come under the spotlight. Agri-food industry in developed countries is undergoing a transformation and adopting supply chain management practices. This change is driven by competition from multinational corporations in the food processing and retailing sector, increasing consumer intolerance towards substandard foods, and increased government regulations for food safety. However, the main concern in agri-food supply chain management is food wastage.

Food wastage is a critical issue in the agri-food industry, and it affects the entire supply chain. When food is not consumed, it becomes waste, regardless of its non-food use. The loss in weight or volume and alteration in physical conditions or characteristics of produce are referred to as 'food loss'. Food loss is a subset of food waste. According to the Food and Agriculture Organization (FAO), it is estimated that one-third of all food produced for human consumption is wasted. This waste has significant economic, social, and environmental implications. The impact of food waste on the three dimensions of sustainability is summarized in Table 1.1. The economic dimension refers to the impact of food waste on profitability. When food is wasted, resources such as land, water, and labor are also wasted, leading to reduced profitability. The social dimension refers to the impact of food waste on people. Food waste affects food security, as many people worldwide suffer from hunger and malnutrition. Food waste also affects the livelihoods of farmers and other stakeholders in the agri-food supply chain.

The environmental dimension refers to the impact of food waste on the planet. Food waste leads to environmental degradation, such as land and water pollution, and contributes to greenhouse gas emissions. Effective management of agri-food supply chain management has significant implications for food waste and sustainability. (Tijaja, 2016) assert that managing the agri-food supply chain effectively requires a holistic approach that considers all aspects of the supply chain. This approach involves the integration of different stages of the supply chain, from production to consumption, and the coordination of different stakeholders, such as farmers, processors, retailers, and consumers. One way to reduce food waste in the agri-food supply chain is by adopting a circular economy approach.

A circular economy involves the reuse, repair, and recycling of products and materials to reduce waste and maximize the value of resources. This approach requires collaboration among stakeholders in the agri-food supply chain to implement measures that reduce food waste, such as improved storage and packaging, and the use of innovative technologies, such as sensors and data analytics. Another approach to reducing food waste in the agri-food supply chain is by adopting sustainable farming practices. Sustainable farming practices involve the use of environmentally friendly methods, such as natural pest control and soil conservation, to produce high-quality food while minimizing the impact on the environment. These practices not only reduce food waste but also improve the quality of food produced, which has a positive impact on the health of consumers.

In conclusion, effective supply chain management is crucial in the agri-food industry to reduce food waste and promote sustainability. Food waste has significant economic, social, and environmental implications and affects the entire agri-food supply chain. Adopting a circular economy approach and sustainable farming practices are some of the ways to reduce food waste in the agri-food supply chain. However, achieving a sustainable agri-food supply chain requires collaboration among stakeholders and the integration of different stages of the supply chain.

Table 1.1: Impacts of food waste on the three dimensions of sustainability

Economic	**Social**	**Environmental**
Reduction in profit	Decrease in nutrition level and increases in susceptibility to micronutrient deficiencies and the related diseases.	Increase in emissions of greenhouse gas methane
Increase in cost for disposal and treatment of waste	Increase in price of food, which negatively affects access.	Non-productive use of water and of agricultural land.
Decrease in financial resources for investment in other sectors	Reduction in labour productivity and wages	Waste of non-renewable energy.

In developed countries, a significant portion of food, ranging from 70% to 80%, is processed before reaching consumers. Rigorous quality standards imposed during agri-food production and produce processing stages are a primary factor contributing to wastage. At the distributor and wholesaler/retailer level, food wastage occurs due to overstocking, while at the household level, it is driven by excessive buying beyond actual needs. Surprisingly, the amount of food wastage at the retail and consumer stages surpasses that occurring earlier in the supply chain. Conversely, in developing countries, food wastage is more prevalent during the immediate postharvest stages. Factors such as inadequate infrastructure, storage facilities, and transportation systems contribute to this trend. For example, in India, there is minimal food wastage from the wholesale market to the consumer level due to a well-established market for all types and grades of products. However, there is a lack of understanding and focus on improving the supply chain upstream of the wholesaler. It is important to analyze supply chains on a region-specific basis since the factors inhibiting waste reduction in agri-food supply chains vary across different areas. The Indian diet primarily consists of vegetables, grains, and pulses, with less emphasis on meat consumption. Therefore, it is crucial to focus on the agri-food sector when addressing food wastage in India. However, most studies on agri-food supply chain management are generic and lack specific regional focus. Additionally, these studies often concentrate on operational issues rather than waste reduction strategies.

India's agriculture sector and population are among the largest in the world, with agriculture contributing to 20% of the GDP and employing 50% of the population. Consequently, gaining an improved understanding of waste reduction in the agri-food supply chain has significant implications for global food security. To address the issue of food wastage in developed countries, measures should be taken to align quality standards with realistic criteria. This can involve reassessing and modifying stringent regulations to allow for the utilization of imperfect produce that may have cosmetic defects but are still safe for consumption. Additionally, fostering consumer education and awareness campaigns can help combat overstocking and encourage responsible purchasing habits at the household level. In developing countries like India, efforts should focus on enhancing postharvest infrastructure, such as storage facilities and transportation systems, to minimize losses occurring immediately after harvest. Investing in technologies like cold storage and refrigerated transportation can significantly extend the shelf life of perishable goods. Furthermore, targeted training programs and knowledge sharing initiatives can help farmers and producers implement best practices for minimizing waste during handling, storage, and distribution processes. It is essential to emphasize region-specific studies and tailor waste reduction strategies to suit the unique factors faced by different areas.

By conducting comprehensive analyses of agri-food supply chains, policymakers and stakeholders can identify the most significant bottlenecks and implement targeted interventions to reduce food wastage effectively. In conclusion, the issue of food wastage in developed countries primarily arises from stringent quality standards, overstocking at distributor and retailer levels, and excessive buying by consumers. Conversely, in developing countries, postharvest stages witness higher levels of food wastage due to inadequate infrastructure. For a country like India, understanding waste reduction in its agri-food supply chain is crucial due to its significant agriculture sector and population. Addressing these factors requires a region-specific approach and a focus on improving infrastructure, implementing best practices, and raising consumer awareness. By reducing food wastage, we can enhance food security not only at the local level but also on a global scale.

1.2. Objective

The main contributions of this study are:

1. This study used a literature review and expert brainstorming to identify 33 factors that hinder waste reduction in the agri-food supply chain (AFSC). The study then utilized Delphi analysis to uncover the underlying relationships among these factors and grouped similar factors into a super-set of nine factors, which represent all other factors within them. This analysis provides a comprehensive understanding of the various factors associated with waste reduction in the AFSC, which is crucial for developing effective waste reduction strategies.
2. The inter-relationship and the respective dominance among these 'nine' factors are determined by using Interpretive Structural Modelling (ISM) and MICMAC analysis; and.
3. Managerial insight is provided which should help all stakeholders, involved in designing and managing the AFSC, to reduce waste and improve sustainable practice.

The application of the ISM Model to the agricultural food waste supply chain allows for an evaluation of the significant risk factors that can impact the transition from conventional production systems to more flexible ones. By employing this model, a comprehensive overview of the most influential factors affecting the desired target can be obtained, enabling better decision-making and resource allocation. This approach helps identify key drivers that facilitate the shift towards more sustainable practices in the agricultural food waste supply chain.

1.3 Theoretical Framework

The authors of this study adopt a pluralistic approach to examine and analyze the interrelationships between risk factors in the transformation of production systems within the agricultural food waste supply chain. The measurement methodology employed consists of two stages. In the initial phase, detailed interviews with global operations managers from various productive organizations are conducted to gather descriptive data for analysis. In the subsequent phase, all identified risk factors are categorized into four groups using the Interpretive Structural Modeling (ISM) technique and a cross-impact matrix. This classification is based on two key aspects: the influence of each risk factor on other detrimental elements within the supply chain, and the impact of other forces on these identified risk factors. By considering these interdependencies, a comprehensive framework is developed and illustrated in Table 1.2, showcasing the relationships between the various risk factors. This approach enables a deeper understanding of how risk factors within the agricultural food waste supply chain are interconnected and influence each other. By mapping out these relationships, decision-makers can gain valuable insights into the most critical risk factors and their potential effects on the overall system. This framework serves as a visual tool to guide strategic decision-making and resource allocation to effectively mitigate and manage risks in the agri-food supply chain, ultimately leading to a more sustainable and efficient system.

The paper is structured as follows: Section 2 examines the relevant literature and contextualizes the current study. Section 3 explains the approach used in this research, including Delphi analysis and ISM. Section 4 presents the findings of the study, while Section 5 analyzes these results. Finally, Section 6 concludes the paper and offers suggestions for future research.

Stage 1 (descriptive data analysis)

1. The identification of thirty-three factors inhibiting reduction of waste in AFSC
2. Questionnaire design
3. Conduct researches
4. Ranking of different risks.

Stage 2 (ISM and cross-impact matrix)

1. Establish a contextual relationship (X) between factors affecting the manufacturing system.
2. Develop a structural self-interaction matrix (SSIM)
3. Develop reachability
4. Partition the reachability matrix into different levels
5. Develop digraph
6. Replace attribute nodes with relationship statements
7. Develop ISM model

Fig. 1.1: Theoretical Framework

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

While most literature on the agri-food supply chain (AFSC) focuses on maximizing firms' revenue and improving consumer satisfaction, reducing food waste is often treated as a secondary objective. This study aims to address this by focusing specifically on reducing waste in plant-based foods, including both long and short shelf-life produce such as grains, pulses, fruits, and vegetables. By prioritizing waste reduction, the study seeks to provide insight into sustainable practices for the AFSC and promote more environmentally conscious behavior in the industry.

With an increasing rate of economic growth. India is on the fast track to progress, thanks to a plethora of causes. However, the Indian logistics industry, which is widely viewed as a barometer of economic health, is disorganized and fragmented, resulting in logistics spending of 14-15 percent of GDP. vs 5-6 percent in developed economies (Jat et al., 2020). The Indian logistics sector is slowly but surely undergoing a disruptive transition. with manufacturing and technology at the forefront. Due to the advent of new digital and analytical capabilities, as well as significant regulatory changes and growing client demands, companies in India must modernize their supply chain methods. In industrialized economies with sophisticated logistics ecosystems, the benefits of digital transformation across the logistics value chain, including warehousing operations. freight transportation. and last-mile delivery. have been demonstrated.(Dwivedi et al., 2020) mentioned the logistics industry is the economy's backbone, and the National Logistics Policy (NLP) will aid in easing bottlenecks and lowering prices. In India, the cost of logistics amounts for around 14% of the country's GDP. The government must bring logistics costs in line with those of other emerging countries by reducing them to 8-10% of GDP. The NLP's wide- ranging reforms will serve as a spark for India's transformation into a $5-trillion economy (Thompson, 2017). We count the ways of how these initiatives and DTs can improve the performance and efficiency of agricultural food supply chain (AFSC)

2.2 Overview of the Research Literature

2.2.1 Concept of Food Supply Chain Management

"The concept of Food Supply Chain Management (FSCM) plays a crucial role in addressing the challenges associated with food production, distribution, and consumption. FSCM involves the coordination and integration of various activities, from sourcing raw materials to delivering the final product to consumers, with the aim of ensuring food safety, quality, and efficiency throughout the entire supply chain (Shukla & Jharkharia, 2013).

This comprehensive approach to managing the food supply chain is driven by the need to reduce food loss and waste, enhance traceability, optimize inventory management, minimize transportation costs, and maintain product freshness (Sharma et al., 2020). FSCM takes into account factors such as demand forecasting, procurement, production planning, inventory control, logistics, and customer satisfaction.

By implementing effective FSCM practices, stakeholders in the food industry can improve collaboration, streamline processes, and achieve better visibility and control over the flow of goods and information. This enables them to respond more effectively to market demands, mitigate risks, and ultimately maximize profitability.

In summary, the concept of Food Supply Chain Management encompasses the strategic coordination and integration of activities involved in food production, distribution, and consumption (Aung & Chang, 2014). By adopting FSCM practices, stakeholders can optimize efficiency, reduce food loss and waste, ensure product quality and safety, and meet consumer expectations."

2.2.2 Requirement of forecasting in AFSC

The technique of forecasting demand, supply, or pricing for a product or a variety of items in a certain industry is known as supply chain forecasting.AI is used in advanced supply chain forecasting to reduce costs and time, increase accuracy, and assist businesses in quickly responding to exceptions. Large volumes of forecasting data may be assimilated by AI-powered supply chain platforms, which can then deliver insightful data to ensure a flexible and agile supply chain (Ahumada & Villalobos, 2009).

There is a lag between supply and demand for vegetables because they are a seasonal commodity. Instead of considering market need, harvesting decisions are made based on experience or guesswork. This is because there isn't a widely used forecasting model. The

farmers are compelled to sell the vegetables to the consolidators at a very low price as a result of these circumstances. This is especially true in developing nations like India, where the majority (98%) of vegetables are sold in open-air markets (Shukla & Jharkharia, 2013). In order to prevent vegetable waste and boost the profitability of all stakeholders, it is necessary to forecast the demand for vegetables in the wholesale market.
To deal with food scandals and events, the food sector needs to respond more quickly and with a greater focus on the customer. Effective traceability systems reduce the manufacturing and distribution of unsafe or subpar goods, reducing the possibility of negative publicity, liability, and recalls (Messner et al., 2021). The authenticity, high quality, and safety of the food cannot be guaranteed by the current system of food labelling. As a result, traceability is used as a tool to help ensure both the quality and safety of food as well as to build consumer confidence.

2.2.3 Supply Chain Risk Management

Supply chain risk management is a large and growing field of research. However, within this field, mathematical models for agricultural products have received relatively little attention. This is somewhat surprising as risk management is even more important for agricultural supply chains due to factors associated with seasonality, supply spikes, long supply lead-times, and perishability (Behzadi et al., 2017). This paper carries out a thorough review of the relatively limited literature on quantitative risk management models for agricultural supply chains. Specifically, we identify robustness and resilience as two key techniques for managing risk. Since these terms are not used consistently in the literature, we propose clear definitions and metrics for these terms; we then use these definitions to classify the agricultural supply chain risk management literature. Implications are given for both practice and future research on agricultural supply chain risk management.

2.2.4 Food Waste And Food Loss

Food waste (FW) has been recognized as a global issue due to its environmental , economic (Chen et al., 2014), and social (Evans, 2011) impacts with global consequences, requiring a change in political actions Food waste and losses mobilize a remarkable amount of natural resources. It consumes around 25% of all water used by agriculture each year 23% of all cropland, equivalent to all cropland in Africa; while it generates around 8% of annual global greenhouse gases (GHG) emissions.

The Food and Agricultural Organization (FAO) reported that approximately one-third of all produced foods (1.3 billion tons of edible food) for human consumption is lost and wasted every year across the entire supply chain. Significant impacts of food loss and waste (FLW) have increased interest in establishing prevention programs around the world. This paper aims to provide an overview of FLW occurrence and prevention. Economic, political, cultural, and socio-demographic drivers of FLW are described, highlighting the global variation. This approach might be particularly helpful for scientists, governors, and policy makers to identify the global variation and to focus on future implications (Ishangulyyev et al., 2019). The main focus here was to identify the cause of the FLW occurrence throughout the food supply chain. We have created a framework for FLW occurrence at each stage of the food supply chain. Several feasible solutions are provided based on the framework.

The amount of food waste needs to be reduced in order to sustain the world's limited resources and secure enough food to all humans. Packaging plays an important role in reducing food waste. The knowledge about how packaging affects food waste in households, however, is scarce. This exploratory study examines reasons for food waste in household and especially how and to what extent packaging influences the amount of food waste. Sixty-one families measured their amount of food waste during seven days and noted in a diary why each item was wasted. Thirty of the families had participated earlier in an environmental project including education in environmental issues of everyday life. About 20–25% of the households' food waste could be related to packaging. Three packaging aspects dominate the packaging related waste: packages that the consumer noted as being too big and packages that were difficult to empty, and wastage because of passed "best before date". The environmentally educated households wasted less, especially of prepared food. They also wasted less food due to passed "best before date". These households were more observant to packaging aspects in relation to food waste (Williams et al., 2012). The observations made could be used to learn more about packaging attributes that affect food waste. Although they recognized packaging influence on food waste, these households expressed lower satisfaction with packaging functions and wanted packaging to a lower extent.

While fulfilling the food demand of an increasing population remains a major global concern, more than one-third of food is lost or wasted in postharvest operations. Reducing the postharvest losses, especially in developing countries, could be a sustainable solution to increase food availability, reduce pressure on natural resources, eliminate hunger and improve

farmers' livelihoods. Cereal grains are the basis of staple food in most of the developing nations, and account for the maximum postharvest losses on a calorific basis among all agricultural commodities. As much as 50%–60% cereal grains can be lost during the storage stage due only to the lack of technical inefficiency. Use of scientific storage methods can reduce these losses to as low as 1%–2% (Kumar, D., & Kalita, 2017). The basics of hermetic storage, various technology options, and their effectiveness on several crops in different localities are discussed in detail.
Policies for preventing food waste are seen in the context of the waste-producing attitudes and behaviors that they target. In order to build successful policy, it is essential to study crucial background information on food waste, including definitions of key words, the history of food waste, the amounts of food waste produced, and the significance of food waste prevention for sustainability.

2.2.5 Sustainable Food Supply Chain

Due to effects on the environment, society, and the economy, the unprecedented level of food waste in the world's food supply chains is receiving more attention, the distinctions between food surplus and waste, preventable and unavoidable food waste, and waste prevention and waste management using interviews with experts in the field. This can be improved by adopting a sustainable production and consumption approach and addressing food surplus and waste along the entire global food supply chain are the first steps towards a more sustainable resolution of the food waste issue (Papargyropoulou et al., 2014).
Businesses and governments are under increasing pressure to focus more on the effects of the continuous expansion of agro-based product production, distribution, and consumption on the environment and resource use. How to ensure producers, especially small farms, are included in sourcing networks and institutional initiatives that support them in adhering to the strict standards for food safety and quality are major concerns in the sustainable development agenda (Naik & Suresh, 2018). Corporates, particularly those involved in retailing, could be crucial in developing sustainable agri-food chains.

2.2.6 Government Policy and Framework

Increased levels of direct connection between supermarkets and farmers and tougher governance structures are commonly seen in conjunction with supply chain reform. Because they regularly discover, small-holder farmers in the aforementioned countries typically encounter greater obstacles as a result of these adjustments (Trebbin, 2014).

Companies aim to improve brand awareness, competitiveness, resource efficiency, customer service, and an image of being socially and environmentally responsible, among other things (Luthra et al., 2015)**.** Companies employ a variety of business strategies to achieve these objectives. For business organizations to become more environmentally friendly, economically viable, and competitive, GSCM has emerged as a critical management tool. It might be a sane strategy from a logical standpoint to stabilize the ecological, monetary, and social gains.

2.2.7 Digitalization Within Food Supply Chains

2.2.7.1 Traceability

The Indian food industry needs traceability to decrease the numerous instances of fraud and food safety incidents as well as the industry's demand for an adequate system because of the current supply chain's vulnerability. Traceability technologies, such as RFID, holograms, barcodes, nuclear methods, and other tracking media, are currently in use in India (Dandage, 2016). Additionally, it is disclosed that APEDA and GS1 India collaborated to develop a variety of ICT projects that are currently being used in several Indian states, including Anarnet, Peanut.net, Meat.net, and Grapenet for Indian agricultural products.

2.2.7.2 Logistics

Even though the majority of publications focus on loss reduction, one significant advantage of FEFO-enabled cold chains is the provision of consistent quality to all stakeholders, which also improves forecasting accuracy and profits. varying businesses may have varying objectives depending on their audience, such as offering high-quality/expensive or low-quality/cheap perishables (Jedermann et al., 2014). The logistical parameters of FEFO cannot be adjusted to take into consideration both types of priorities without a detailed forecast of the distributed inventory's shelf life. High-quality perishables can be made available to customers at a premium price by choosing products with a comparatively extended shelf life to be delivered in shorter periods of time and vice versa.

CHAPTER 3

RESEARCH METHODOLOGY

The study that was done involves figuring out how certain barriers related to one another in order to create a structural model. Using a two-phase hybrid research technique, the adoption barriers of DTs in AFSC were demonstrated in this study. The literature review was examined and analysed in the first phase. with one round of Delphi study to identify key barriers to DTS adoption in AFSC.

ISM was used in the second phase to produce a hierarchical structure or inter-relationship between the barriers that had been identified. The Interpretive Structural Modeling (ISM) approach was used to accomplish this. The relationship between the barriers was discovered using ISM, and a structural model was then created. This gave insights into how the selected obstacles interact and depend on one another, improving our understanding of these relationships. The resulting model can be used to assist in decision-making and the formulation of strategies, assisting in overcoming obstacles and achieving the intended results.

3.1 Phase 1: DELPHI METHOD

The Delphi method is a quantitative and methodical approach of predicting that involves interviewing a group of experts via numerous rounds of questionnaires. These experts should have in-depth knowledge of a topic in order to forecast future scenarios, predict the possibility of an event, and finally form an agreement on the subject at hand (Campos-Climent et al., 2012). The Delphi method, also known as the estimate-talk-estimate methodology. is a process for estimating, talking about, and estimating (ETE). Several rounds of written surveys are used in the Delphi technique. to which experts respond with their opinions. This method necessitates the use of a facilitator who will review the data and provide a summary report. Each batch of questionnaires is answered by specialists. The facilitator then compiles all of the responses and distributes a summary report to each expert. The experts go over the summary report and agree or disagree with the replies of the other experts. The experts then complete a second questionnaire, which allows them to submit updated comments based on what they've learned from the summary report. When a consensus of forecasts is reached, the Delphi procedure is complete.

3.1.1 Delphi Method Process: (Okoli & Pawlowski, 2004)

Step 1. Identify the Issue and Objective

It's critical to define the problem we're trying to address and the goals we want to accomplish with the Delphi technique. It's critical to understand the goal, or what we're trying to anticipate.

Step 2. Choose a Facilitator

The first step is to choose the facilitator. The facilitator should take a neutral position and be someone with experience with research and data collection.

Step 3. Identify the Experts

The Delphi technique relies on a panel of experts. An expert is any individual with relevant knowledge and experience of a particular topic. Delphi participants must meet four "expertise" requirements (J. Skulmoski et al., 2007) which are:

- Knowledge and experience about the problem under investigation.
- Ability and willingness to participate.
- Enough time to participate in the Delphi.
- Effective Communication Skills.

1. Round one Questionnaire

The first questionnaire is given to the experts by the facilitator. Round one questions are frequently open-ended, allowing experts to brainstorm their responses. The facilitator compiles all of the responses to the questionnaire and distributes a summary report to the experts. The experts' identities are kept secret in the summary report to encourage them to express themselves freely.

11. Round two Questionnaire

The second questionnaire should be constructed by analysing the prior round's responses. Similarities and irrelevant information should be found and removed. These aids the second round of questions in heading in the direction of expert consensus. After reading the first-round summary report and comprehending the viewpoints of other experts, an expert's opinion may not alter if they respond to the second questionnaire. The facilitator will provide the experts a second summary report of the answers after they have completed the second questionnaire.

III. Round three Questionnaire

Carry on with the same strategy as the previous rounds in the third round. The answers to the second questionnaire should be used to build the third questionnaire. Based on the comments from the second-round answer summary report, experts will complete the third questionnaire. We can stop if there is enough agreement among specialists and all projections appear to be in line with one another. Otherwise, we have the option of continuing.

3.1.2 Practical Applications:

The Delphi technique was first employed in the realm of science and technology to forecast trends and results. It's used to forecast technology developments in aero- space, automation, broadband connections, and schools, for example.

- It is also used to forecast economic, educational, health-care, and public-policy consequences. It's also valuable in the workplace, where it may help you estimate sales with a 96 percent to 97 percent accuracy when compared to actual sales. As a result, the Delphi technique may be used to anticipate how successful business events will be.

3.1.2. Factors inhibiting the waste in AFSC:

Despite the fact that there are numerous promising examples of good impacts on rural livelihoods, various start-ups were launched in previous years, various decisions and initiatives were taken but they have not been scaled up to the amount that would be expected, and the reason lies within the ASCM.

A review of the literature and a consultation with experts in the Indian food industry and academia leads to the identification of factors inhibiting reduction of waste in AFSC. Table 3.1 provides the profile of these experts and Table 3.2 provides the description of the 33 factors identified. In this section, the application of Delphi method, ISM, and MICMAC methods, is discussed.:

Table 3.1: Experts

Expert number	Type of Activity	Designation
1	Aggregator & Producer	Chief Executive
2	Organised Retailer	Store Manager
3	Food Processor	Manager Operations
4	Academics	Professor
5	Storage	Owner of cold store

Company Name: Jubilant Food work, Haldiram, Shivang Cold Storage, Mother Dairy, Grofers

Name: Vinod Saxena, Pradipta, Kuldeep, Yash Gupta, Madhav Agarwal, Shivanshu Kaushik, Rahul Arora

Designation: Restaurant manager, Store Manager, Manager operation, Executive in Maintenance, Cold Chain & Food Processing, Dark Store Manager

Table 3.2: Identified Factors

S. No.	Scale Item	Source	Description
1	Imbalance Procurement Channel	(Sharma et al., 2020)	Procurement channels comprise: requisition, purchase and invoice channels, and facilitate Purchase-to-Pay process while maintaining user-friendliness, control & visibility, and efficiency
2	Poor Transportation Network	(Sharma et al., 2020)	A transportation network is a realisation of a spatial network, whose objective is to deliver commodities at the agreed time and at the agreed location
3	Lack of Partnership among stakeholders	(Aung & Chang, 2014)	Cooperation implies having a common goal and a positive attitude towards each other. It does not imply a close working relationship

4	Lack of Coordination	(Ahumada & Villalobos, 2011)	Coordination implies a close working relationship and joint decision-making
5	Complex Market System	(Teigiserova et al., 2019)	The market system helps bidders and sellers interact and make deals. It is the system of regulation, credentials, reputation, and clearing, in a social context, which surrounds the price mechanism
6	Inefficient distribution network	(Shukla & Jharkharia, 2013)	A distribution network is the configuration of the facilities to transfer goods from the supply to the demand points in the best possible manner. The design decision involves the number of facilities, their function, and their location.
7	Lack of trust	(Aung & Chang, 2014)	Trust refers to a firm's expectation that their partners will act to benefit their (firm's) interests regardless of their ability to monitor such behaviour
8	Lack of supply chain contracts	(Gokarn & Kuthambalayan, 2018)	Clauses in the contract aim to achieve coordination by providing a suitable incentive to both parties.
9	Lack of Communication	(Chauhan et al., 2021)	Communication ensures smooth operations by providing visibility and information across the supply chain
10	Lack of technical expertise	(Shukla & Jharkharia, 2013)	Technical expertise refers to a persons' knowledge or skill and his ability to perform a particular task well.
11	Lack of traceability	(Aung & Chang, 2014)	It refers to the knowledge of life history of a product
12	Lack of technical support	(Chauhan et al., 2021)	Technical support refers to the help and advice provided by a firm, about their products, to its customers.
13	Poor operational facility	(Reddy et al., 2010)	Processing of food serves to prevent spoilage and retain its nutritive value.

14	Inefficient Cold Chain & storage	(Shashi, S., Cerchione, R., Singh, R., Centobelli, P., & Shabani, 2018)	A cold chain refers to the refrigerated storage and distribution activities.
15	Lack of Harvesting Planning	(Shukla & Jharkharia, 2013)	The timing of planting and harvesting are dictated by market conditions and the biological nature of the grower's product
16	Poor packaging efficiency	(Williams et al., 2012)	It is the ability to package products with minimum damage or loss.
17	Poor storage facility	(Ishangulyyev et al., 2019)	It refers to the available infrastructure for storage of produce at intermediaries in the supply chain.
18	Lack of Transportation Planning	(Tsolakis et al., 2014)	It refers to the transportation of produce such that it reaches the destination at the agreed time in a convenient, economical, and environment-friendly manner
19	Bulkiness (Size)	(Naik & Suresh, 2018)	The bulkiness of the fresh produce adds to the transportation, handling and packaging difficulty
20	Attitude of Consumer	(Papargyropoulou et al., 2014)	It refers to the consumers' intolerance of sub-standard foods, which includes any cosmetic defects such as blemishes and misshapen produce
21	Habits of Consumer	(Papargyropoulou et al., 2014)	It refers to the consumer habit of throwing away food.
22	Consumer Mentality	(Papargyropoulou et al., 2014)	It refers to the purchasing in excess of need
23	Demand uncertainty	(Chauhan et al., 2021)	Demand uncertainty refers to the difficulty in accurately projecting customer demand in the future. Even if the average consumer demand is stable, weather changes and changing

24	Supply uncer-tainty	(Chauhan et al., 2021)	It refers to variations in supply quantity because of human behaviour (e.g., shortage gaming and forward buying because of price discounts) beside other reasons.
25	Price uncertainty	(Simangunsong et al., 2012)	The uncertainty is in the price the farmers receive for their produce.
26	Process uncer-tainty	(Simangunsong et al., 2012)	Natural factors cause uncertainty in crop yields.
27	Quality variation	(Kumar, D., & Kalita, 2017)	Quality refers to variation in nutrient composition of the produce due to genetics, pre-harvest condi-tions, the maturity of the produce at harvest, post-harvest handling and storage conditions, and pro-cessing techniques employed
28	Seasonality	(Naik & Suresh, 2018)	Seasonal climate influences area planted or har-vested and the number of crops grown (besides yield).
29	Perishability	(Naik & Suresh, 2018)	It is a characteristic of the produce which causes it to spoil, decay or become unsafe to consume if not kept refrigerated
30	Lack of quality & safety measures	(Aung & Chang, 2014)	It refers to food control systems to protect public health, prevent fraud and deception, and avoid food adulteration by means of legislation, infra-structure, and enforcement mechanisms.
31	Awareness in Consumer	(Papargyropoulou et al., 2014)	It refers to the awareness of consumers of wasted food generally, and the amount of food they waste.
32	Inadequate food policy	(Kotsanopoulos & Arvanitoyannis, 2017)	Food policy is concerned with meeting or further-ing social objectives.
33	Poor Regula-tions	(Behzadi et al., 2017)	It refers to regulating food industry behaviours, such as marketing unhealthy foods and promoting

			purchase in large portions, which contribute to poor diet and waste.

Even though the government and agricultural groups are taking steps and creating applications and launching beneficiary schemes, the results are not satisfactory.

3.2 ISM Modelling:

A sophisticated system's structural model can be created using the ISM (Interpretive Structural Modelling) methodology, which is utilised in systems analysis and management. It is a qualitative modelling approach that is frequently used to investigate the connections and interdependencies between the different parts of a system.

Gregory N. Stock and Robert L. Keeny first presented the ISM method in 1982. The methodology is founded on the notion that by examining the interdependencies between a complex system's numerous components, its structure may be understood. ISM entails a set of stages that start with identifying the essential elements of a system, study how they interact, and then develop a hierarchical model to describe these interactions.

ISM modelling uses expert knowledge and judgement to pinpoint a system's constituent parts and their interrelationships. The technique can be used to discover crucial aspects and prospective intervention areas, and it is especially helpful in circumstances where data is scarce or lacking.

The resulting model is a graphic representation of the system, with nodes denoting its constituent parts and links denoting its interrelationships. The model can be used to pinpoint crucial system elements, possible intervention locations, and to investigate the potential effects of system modifications. ISM modelling is widely used in a variety of fields, including management, engineering, and public policy, and it has been used to analyse complex systems ranging from transportation networks to healthcare systems.

3.2.1 Application of ISM method

In ISM method, experts from academia and industry were consulted for inputs needed to establish relationships among factors. ISM methodology is thus interpretive in nature. It creates an understanding of the interactions among factors and their in-between structure (by arranging the factors into a hierarchy). The ISM approach is as follows:

1. Determine pair-wise relationships among the factors to obtain a structural self-interaction matrix (SSIM).

2. Determine the transitivity relationships to obtain a reachability matrix from SSIM.
3. Partition the reachability matrix into different levels.
4. Develop the ISM model based on the final reachability matrix and the outcome of level partition.
5. Check the conceptual inconsistency of the ISM based model and make necessary modifications.

3.2.2 Development of SSIM

To develop SSIM, the opinion of experts on the relationship between factors is used. One of four symbols ('V', 'A', 'X', 'O') is used to understand the relationship between any two factors (i and j), and the direction of this relationship,

- V: If factor *i* influences factor *j*
- A: If factor *j* influences factor *i*
- X: If factor *i* and *j* influence each other
- O: If factor *i* and *j* are unrelated.

The outcome of these contextual relationships for the identified factors is the SSIM.

3.2.3 Development of Reachability Matrix

The reachability matrix is developed from SSIM in two steps. The first step consists of determining the initial reachability matrix, a binary matrix. It is the result of substituting V, A, X, and O with '1' or '0' in SSIM, using the convention stated below:

- If the notation in the cell (i, j) is 'V', then, the cell (i, j) notation is converted into '1' and the cell (j, i) notation is converted into '0'.
- If the notation in the cell (i, j) is 'A,' then the cell (i, j) notation is converted into '0' and the cell (j, i) notation is converted into '1'.
- If the notation in the cell (i, j) is 'X', then the notations in both the cells (i, j) and (j, i) is converted into '1'.
- If the notation in the cell (i, j) is 'O', then the notations in both the cells (i, j) and (j, i) are converted into '0'.

The second step consists of using the transitivity rule to obtain the final reachability matrix of the factors. This rule says that if a variable X is related to a variable Y, and the variable Y is related to a variable Z, then the variable X is also related to the variable Z. This rule is used to establish a relationship between factors X and Z, which have no in between relationship in the initial reachability matrix.

3.2.4 Level Partitions

The reachability set for a particular factor consists of the factor itself and the factors, which it may influence. The antecedent set consists of the factor itself and the factors, which influence it. The intersection of these two sets is determined. The factor, for which the reachability and the intersection sets are equivalent, is assigned to different Level in the ISM hierarchy model, as it would not influence any other factors above its own level. These factors are then discarded from the list. The above process is repeated until each factor is assigned to a level.

3.2.5 Formation of ISM based model

A directed graph (digraph), based on the final reachability matrix and outcome of level partition, is drawn. The digraph is converted into an ISM model, by removing the transitivity relation between them. MICMAC analysis classifies the identified factors into four categories, autonomous, dependent, linkage and independent, based on their driving and dependence powers (Gorane & Kant, 2013), and its application is discussed next.

3.3 MICMAC Analysis

The management of a factor with high driving value helps overcome the factors dependent on it. The nine factors are classified into four categories, based on their drive and dependence powers, as follows:

- Autonomous factor (Quadrant-I): The factor with weak drive and dependence powers. The system is relatively unaffected by this factor.
- Dependent factor (Quadrant - II): The factors with weak drive power, but strong dependence power.
- Linkage factor (Quadrant - III): The factor with strong drive and dependence powers.
- Independent factor (Quadrant - IV): The factor with strong drive power, but weak dependence power. These are the ‘key’ factors.

The basis of categorisation is the multiplication properties of matrices (Gorane & Kant, 2013). The driving power and dependence power of each factor are computed by adding the values along the row for driving power and along the column for dependence power. On the basis of these values, a graph is plotted for each factor, by treating corresponding dependence and driving power as ‘X’ and ‘Y’ coordinates, respectively.

3.4. Roadmap:

Using the ISM technique, the interrelationships among adoption barriers were incorporated in this study. The complete roadmap of the methodology of study is shown in fig.

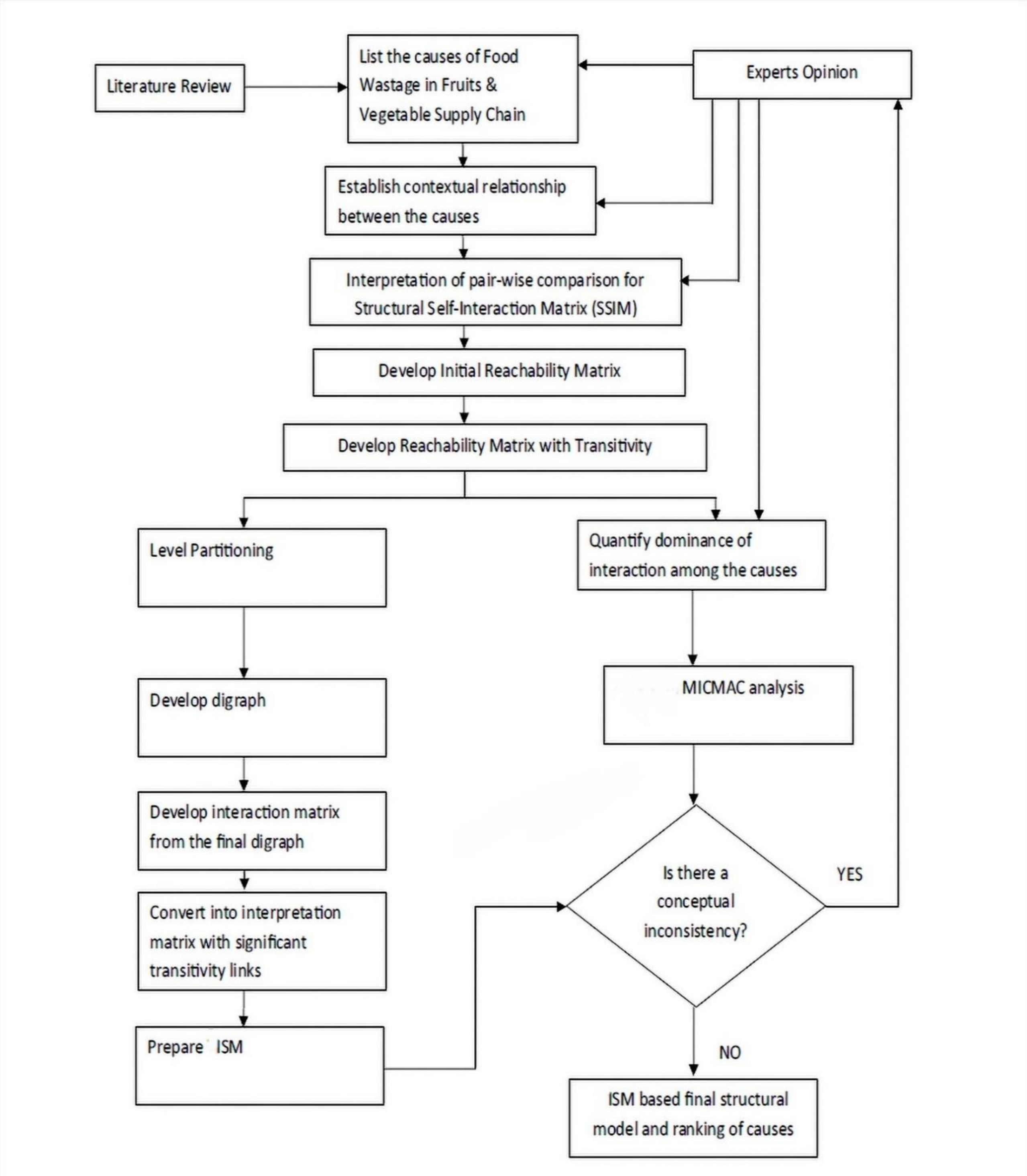

Fig. 3.1: Roadmap of the methodology of study

3.5 Role of Experts in Grouping Similar Factors into a Super-Set of Nine

In the complex domain of the agro-food supply chain, the issue of waste has emerged as a significant concern. To tackle this challenge, a comprehensive analysis was conducted, encompassing a total of 33 distinct factors that contribute to waste generation. These factors encompassed various aspects such as production, transportation, packaging, storage, and consumer behavior. Recognizing the need for a structured approach, a team of experts specializing in the field collaborated to group these factors into a super-set comprising nine overarching categories. This collaborative effort was instrumental in identifying commonalities and interdependencies among the 33 factors. By clustering them into related groups, a more coherent and manageable framework was established, allowing for a deeper understanding of the waste generation process within the agro-food supply chain. The experts drew upon their extensive knowledge and experience to discern patterns and connections that might otherwise go unnoticed.

The resulting super-set factors served as a valuable tool for stakeholders within the agro-food industry. This framework not only provided a holistic view of the waste-related challenges but also enabled targeted interventions and mitigation strategies. By addressing the specific factors within each category, stakeholders could streamline operations, implement sustainable practices, and minimize waste generation throughout the supply chain. Moreover, the involvement of experts ensured that the grouping process was rigorous and informed by industry best practices. Their expertise added credibility and rigor to the analysis, enhancing the overall reliability of the derived super-set factors. The collaborative nature of this endeavor fostered a multidimensional perspective and promoted knowledge sharing, ultimately leading to more effective waste management strategies in the agro-food supply chain.

Table 3.3: Categorized Factors

S.No	Scale Items	Factors
1	Perishability	Preparation Error (F1)
2	Quality Variation	
3	Seasonality	
4	Bulkiness	
5	Price Uncertainty	Supply Chain Uncertainty (F2)
6	Demand Uncertainty	
7	Supply Uncertainty	
8	Process Uncertainty	
9	Lack of Technical Expertise	Technical Support (F3)
10	Lack of Tracking Technology	
11	Lack of Traceability	
12	Lack of Communication	
13	Lack of Partnership among stakeholders	Supply Chain Coordination (F4)
14	Lack of Trust	
15	Lack of Coordination	
16	Lack of Supply Chain Contracts	
17	Lack of Harvesting Planning	Processing Capability (F5)
18	Lack of Transportation Planning	
19	Packaging Inefficiency	
20	Poor Storage Facility	
21	Consumer Mentality	Consumerism (F6)
22	Awareness in Consumer	
23	Attitude of Consumer	
24	Habits of Consumer	
25	Complex Market System	Inefficient Infrastructure (F7)
26	Inefficient Cold Chain & storage	
27	Poor Operational Facility	
28	Inadequate Food policy	Policy & Framework (F8)
29	Poor Regulations	
30	Lack of Quality and Safety measure	
31	Poor Transportation Network	Distribution Network (F9)
32	Imbalance Procurement channel	
33	Inefficient Supply Chain Network	

1) **Preparation Error (F1):** Preparation mistakes in the agricultural food supply chain can lead to infection, spoiling, and system disruption. Examples of preparation mistakes include improper handling and processing of food supplies, poor facilities for storage and transportation, and a lack of planning for natural disasters and unforeseen events. In order to avoid these mistakes, effective management systems for food safety and quality should be in place, and stakeholders should receive the right kind of instruction and training. To reduce errors and maintain the efficient operation of the agriculture food supply chain, investment in infrastructure, technology, and logistics is also crucial.
2) **Supply Chain Uncertainty (F2):** The agriculture food supply chain is vulnerable to a number of unpredictabilities, including weather occurrences, shifts in commodity prices, delays in transportation, and governmental regulations. These unknowns may have an impact on food production, distribution, and consumption, possibly resulting in food shortages, poor quality, and unstable prices. Extreme weather conditions like droughts or floods, for instance, can affect crop yields and harvest times, while trade regulations or border restrictions can restrict access to vital markets or inputs. Agriculture food supply chain stakeholders, such as farmers, suppliers, processors, distributors, retailers, and policymakers, must work together and coordinate efforts to manage and reduce supply chain uncertainty.
3) **Technical Support (F3):** The agricultural food supply chain needs technical support since it helps to maximize production and ensure the quality and safety of food items. Several tasks fall under the category of technical support, including soil analysis, crop monitoring, pest control, irrigation, and post-harvest handling. In order to increase productivity and decrease waste, it may also involve the use of technology and data analytics. Agronomists, extension agents, consultants, and technology firms can all offer technical support. For the agriculture food supply chain to be sustainable and resilient and to be able to manage issues like climate change, resource scarcity, and market volatility, access to high-quality technical support is a necessity.
4) **Supply Chain Coordination (F4):** In order to maintain an effective flow of goods from producers to consumers, supply chain coordination is crucial in the agriculture and food industries. Involved parties like farmers, processors, distributors, retailers, and governmental organisations may work together as part of coordination. Reduced waste, optimal inventory levels, and improved product quality and safety are just a few ways that effective coordination can boost supply chain performance. Also, it can increase producers'

access to the market and give customers more options and product availability. Contracts, standards, certifications, and platforms for information sharing can all be used as coordination methods. It takes cooperation from all parties involved in the supply chain in the form of trust, openness, and communication in order to ensure effective supply chain coordination.

5) **Processing Capability (F5):** The term "processing capability" in the context of the agriculture food supply chain describes the capacity of the food processing sector to effectively and efficiently convert agricultural raw materials into safe, wholesome, and food products with added value. The ability to process encompasses a number of steps, including cleaning, sorting, grading, packaging, and food preservation. The efficiency and efficacy of the processing capability are crucial in assuring the availability and affordability of high-quality food products for consumers while minimising food waste and losses. The sector has been able to increase its processing capacity, lower costs, improve food safety and traceability throughout the supply chain, and innovate.

6) **Consumerism (F6):** Consumerism in the agricultural food supply chain is the tendency for consumers to have a bigger say in how food is produced and distributed. Consumer preferences for particular food goods, such as organic or locally farmed produce, are a common example of this. Farmers and food producers may respond by changing their ways to satisfy these expectations, such as employing less pesticides or more sustainable farming techniques. Consumerism can also spur innovation in the food sector, creating new goods and procedures that better satisfy consumer demands. If not handled appropriately, it can also result in food waste and environmental harm.

7) **Inefficient Infrastructure (F7):** In the agricultural food supply chain, ineffective infrastructure can cause delays, food deterioration, and food product waste. This could happen during different phases of the supply chain, like distribution, storage, and transportation. For instance, inadequate refrigeration or storage facilities can result in food goods spoiling or degrading, costing farmers and other manufacturers a lot of money. Ineffective transportation methods can also cause delays and higher expenses, which lowers the supply chain's overall effectiveness. Infrastructure improvements including modernising transportation networks, upgrading storage facilities, and putting more cutting-edge technologies in place to better monitor and control the supply chain may be necessary to address these inefficiencies.

8) **Policy & Framework (F8):** Regulations and frameworks in the agriculture food supply chain can support efficient and sustainable practises while also guaranteeing the safety and high quality of food products. These rules can be in the shape of standards for food labelling and packaging, restrictions on the use of pesticides and other chemicals, or financial incentives for farmers and other producers to adopt sustainable practises. Frameworks can be established to keep an eye on and trace the supply chain, enhancing accountability and transparency for all parties. In general, rules and policies can be crucial in ensuring that the agriculture food supply chain functions in a way that benefits producers, consumers, and the environment.
9) **Distribution Network (F9):** The method used to move food from producers to consumers is referred to as the distribution network in the agriculture food supply chain. This network frequently includes a variety of actors, including wholesalers, distributors, and retailers. Each of these actors is essential to ensuring that food supplies arrive at their intended locations quickly and efficiently. Reducing waste, ensuring product quality and safety, and improving customer access to food goods are all possible with efficient distribution networks. However, issues like poor infrastructure, restricted access to transportation, and supply chain disruptions can all have an impact on the effectiveness and efficiency of distribution networks, underscoring the need for continuous innovation and investment in this important part of the agriculture food supply chain.

CHAPTER 4
RESULT AND DATA ANALYSIS

The study was carried out in two stages:

Stage 1: One-round Delphi study was conducted in the first phase to acquire information and conceptual understanding of the identified barriers. Based on the experts' perspective. the discovered barriers in the literature were examined with practitioners and divided into ten critical barriers and their sub-barriers. The experts were chosen using the Delphi technique for validations from various government and business organisations.

Stage 2: Questionnaires were prepared based on the proposed barriers identified in Stage 1. To assist the respondents, the questionnaires included a brief explanation and clarification of each barrier. According to the ISM methodology, this information was gathered in a predefined format and finally. created an ISM Model using the barriers.

4.1 Stage I: DELPHI ANALYSIS

Step 1: For the final list of barriers, all of the identified barriers from the literature were discussed with industry professionals. Through expert interviews. these impediments were divided into ten critical barriers. each with its own critical elements. There were important factors associated with each barrier that could be considered sub-barriers. The sub-barriers that are being studied are industry-specific and have been classified based on expert recommendations (see Table 02).

4.2 Stage II: ISM MODEL

Step 2: Experts now used pairwise comparison to determine the contextual relationships among all of the barriers.

V: parameter i will lead to parameter j.

A: parameter j will lead to parameter i.

X: parameter i and j will lead to each other.

O: parameters i and j are unrelated.

Step 3: Development of SSIM Matrix take place using above mentioned technique (see Step-3).

4.3 Result of ISM method

4.3.1 SSIM

Table 4.1 provides the SSIM (contextual relationships for the nine factors).

Table 4.1: Structural self-intersection matrix (SSIM)

S/N	List of Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9
F1	Preparation Error	1	V	V	V	V	V	V	V	V
F2	Supply Chain Uncertainty		1	V	V	V	V	V	O	V
F3	Technical Support			1	V	V	O	A	A	V
F4	Supply Chain Coordination				1	O	O	O	O	A
F5	Processing Capability					1	V	A	A	V
F6	Consumerism						1	A	A	O
F7	Inefficient Infrastructure							1	O	V
F8	Policy & Framework								1	V
F9	Distribution Network									1

4.3.2 Reachability Matrix

Table 7 provides the initial reachability matrix, and the final reachability matrix of the factors.

Table 4.2: Initial Reachability matrix

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9
F1	1	1	1	1	1	1	1	1	1
F2	0	1	1	1	1	1	1	0	1
F3	0	0	1	1	1	0	0	0	1
F4	0	0	0	1	0	0	0	0	0
F5	0	0	0	0	1	1	0	0	1
F6	0	0	0	0	0	1	0	0	0
F7	0	0	1	0	1	1	1	0	1
F8	0	0	1	0	1	1	0	1	1
F9	0	0	0	1	0	0	0	0	1

Table 4.3: Final reachability matrix

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	Driving Power
F1	1	1	1	1	1	1	1	1	1	9
F2	0	1	1	1	1	1	1	0	1	7
F3	0	0	1	1	1	1*	0	0	1	5
F4	0	0	0	1	0	0	0	0	0	1
F5	0	0	0	1*	1	1	0	0	1	4
F6	0	0	0	0	0	1	0	0	0	1
F7	0	0	1	1*	1	1	1	0	1	6
F8	0	0	1	1*	1	1	0	1	1	6
F9	0	0	0	1	0	0	0	0	1	2
Dependence Power	1	2	5	8	6	7	3	2	7	

4.3.3 Level Partitions

Table 7 shows that all the nine factors achieve their level after seven iterations.

Table 4.4: Iteration 1

Elements	Reachability Set	Antecedent Set	Intersection Set	Level
1	1, 2, 3, 4, 5, 6, 7, 8, 9,	1,	1,	
2	2, 3, 4, 5, 6, 7, 9,	1, 2,	2,	
3	3, 4, 5, 6, 9,	1, 2, 3, 7, 8,	3,	
4	4,	1, 2, 3, 4, 5, 7, 8, 9,	4,	**I**
5	4, 5, 6, 9,	1, 2, 3, 5, 7, 8,	5,	
6	6,	1, 2, 3, 5, 6, 7, 8,	6,	**I**
7	3, 4, 5, 6, 7, 9,	1, 2, 7,	7,	
8	3, 4, 5, 6, 8, 9,	1, 8,	8,	
9	4, 9,	1, 2, 3, 5, 7, 8, 9,	9,	

Table 4.5: Iteration 2

Elements	Reachability Set	Antecedent Set	Intersection Set	Level
1	1, 2, 3, 5, 7, 8, 9,	1,	1,	
2	2, 3, 5, 7, 9,	1, 2,	2,	
3	3, 5, 9,	1, 2, 3, 7, 8,	3,	
5	5, 9,	1, 2, 3, 5, 7, 8,	5,	
7	3, 5, 7, 9,	1, 2, 7,	7,	
8	3, 5, 8, 9,	1, 8,	8,	
9	9,	1, 2, 3, 5, 7, 8, 9,	9,	**II**

Table 4.6: Iteration 3

Elements	Reachability Set	Antecedent Set	Intersection Set	Level
1	1, 2, 3, 5, 7, 8,	1,	1,	
2	2, 3, 5, 7,	1, 2,	2,	
3	3, 5,	1, 2, 3, 7, 8,	3,	
5	5,	1, 2, 3, 5, 7, 8,	5,	**III**
7	3, 5, 7,	1, 2, 7,	7,	
8	3, 5, 8,	1, 8,	8,	

Table 4.7: Iteration 4

Elements	Reachability Set	Antecedent Set	Intersection Set	Level
1	1, 2, 3, 7, 8,	1,	1,	
2	2, 3, 7,	1, 2,	2,	
3	3,	1, 2, 3, 7, 8,	3,	**IV**
7	3, 7,	1, 2, 7,	7,	
8	3, 8,	1, 8,	8,	

Table 4.8: Iteration 5

Elements	Reachability Set	Antecedent Set	Intersection Set	Level
1	1, 2, 7, 8,	1,	1,	
2	2, 7,	1, 2,	2,	
7	7,	1, 2, 7,	7,	**V**
8	8,	1, 8,	8,	**V**

Table 4.9: Iteration 6

Elements	Reachability Set	Antecedent Set	Intersection Set	Level
1	1, 2,	1,	1,	
2	2,	1, 2,	2,	**VI**

Table 4.10: Iteration 7

Elements	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,	1,	1,	**VII**

Table 4.11: Level Partitions of Factors

Elements	Reachability Set	Antecedent Set	Intersection Set	Level
1	1, 2, 3, 4, 5, 6, 7, 8, 9,	1,	1,	**VII**
2	2, 3, 4, 5, 6, 7, 9,	1, 2,	2,	**VI**
3	3, 4, 5, 6, 9,	1, 2, 3, 7, 8,	3,	**IV**
4	4,	1, 2, 3, 4, 5, 7, 8, 9,	4,	**I**
5	4, 5, 6, 9,	1, 2, 3, 5, 7, 8,	5,	**III**
6	6,	1, 2, 3, 5, 6, 7, 8,	6,	**I**
7	3, 4, 5, 6, 7, 9,	1, 2, 7,	7,	**V**
8	3, 4, 5, 6, 8, 9,	1, 8,	8,	**V**
9	4, 9,	1, 2, 3, 5, 7, 8, 9,	9,	**II**

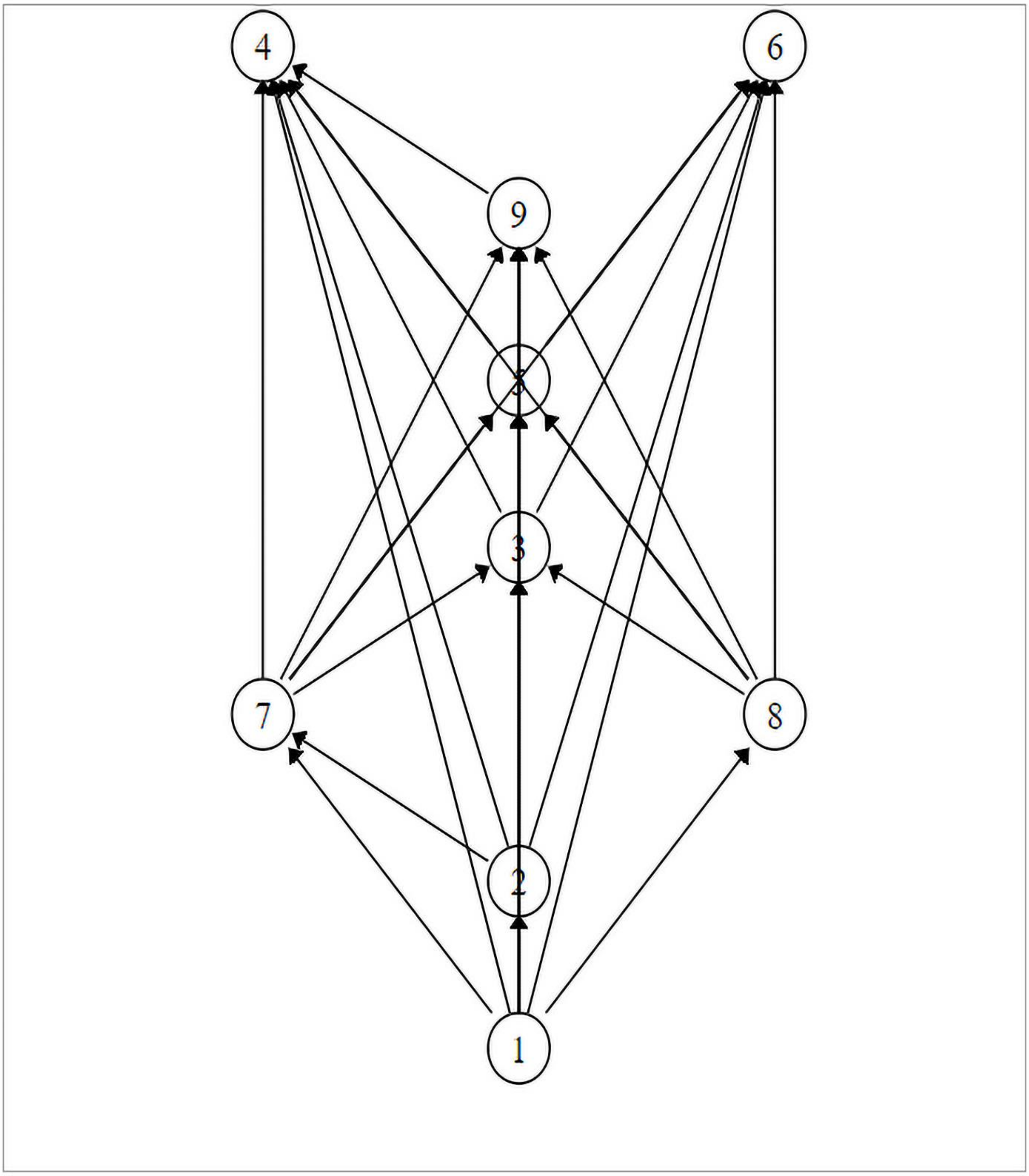

Fig 4.1: Digraph

4.3.4 ISM based model

Figure 1 shows the ISM model developed. Model has seven levels of hierarchy, Level I to Level VII.

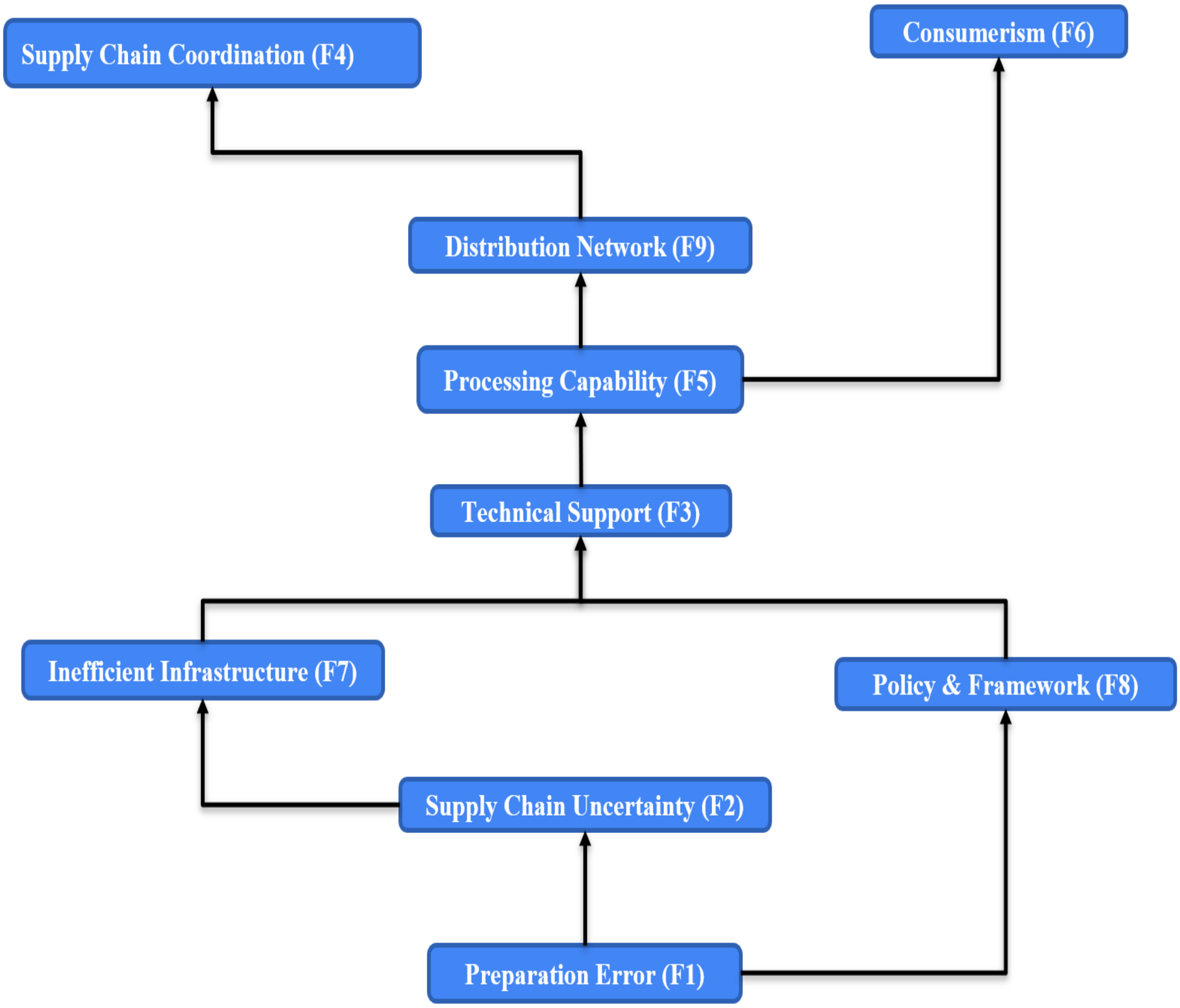

Fig. 4.2: ISM Model

4.3.5 Result of MICMAC Analysis

Table 7 shows the driving power and dependence power of each factor. Figure 4 shows the graph plotted on the basis of these values.

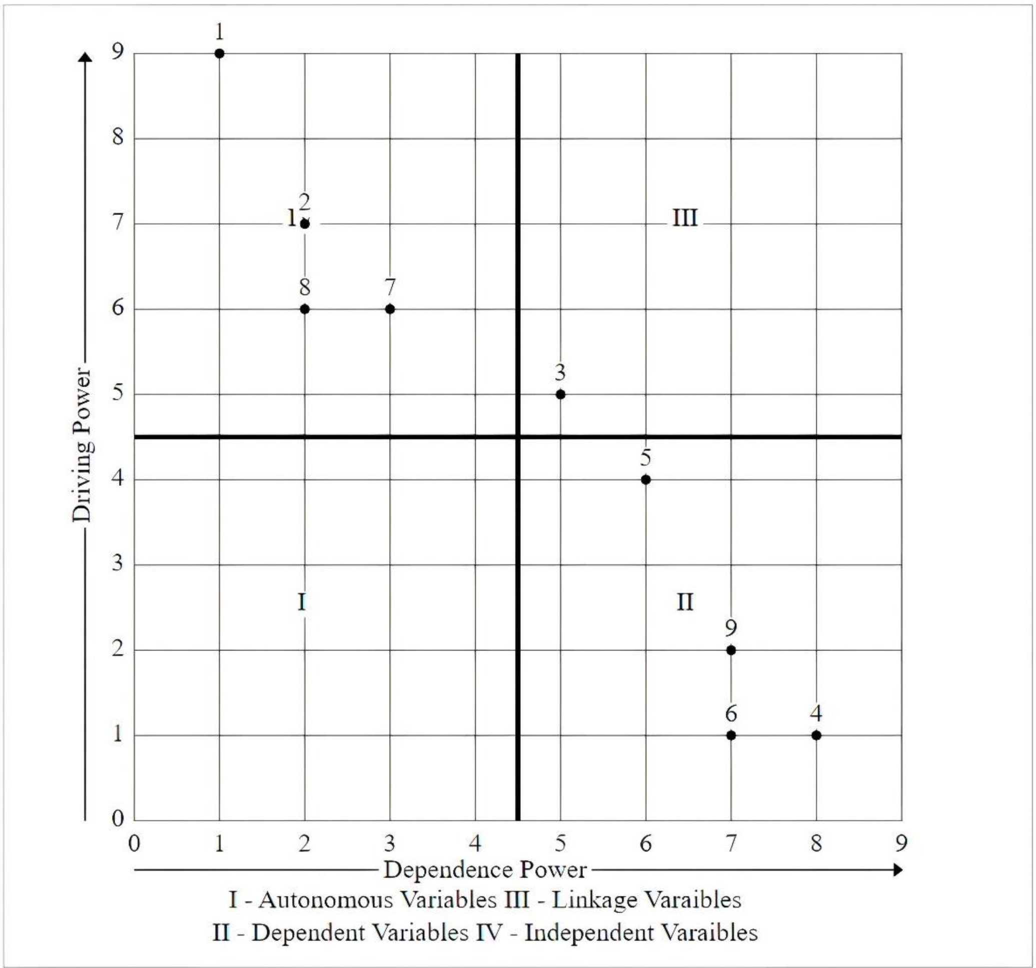

Fig. 4.3: MICMAC Analysis

4.4 Discussion And Result

The ISM model, as depicted in Figure 3, provides valuable insights into the various factors contributing to the successful reduction of food waste in the AFSC (Agricultural and Food Supply Chain). It presents a hierarchical structure where factors are categorized into different levels, indicating their relative importance. At the top level (Level-1), Consumerism (F6) and Supply Chain Coordination (F4) emerge as key factors. These factors play a vital role in addressing the factors associated with food waste reduction. Moving down to Level-2, we find Distribution Network (F9), which encompasses issues like inefficient transportation networks, imbalanced procurement channels, and an inefficient supply chain network. Effective management of Level-2 factors can contribute to addressing the factors at Level-1. Further down the hierarchy, Level-3 consists of Processing Capability (F5), while Technical Support (F3) occupies Level-4. Level-5 encompasses Inefficient Infrastructure (F7) and Policy and Framework (F8). Supply chain uncertainty (F2) is positioned at Level-6, and Preparation error (F1) at Level-7. It is worth noting that management of factors at higher levels, such as Level-6 and Level-7, holds the greatest potential for aiding in the management of factors at lower levels. For instance, addressing quality variations can have an impact on reducing demand and supply uncertainties throughout the supply chain. In summary, the hierarchical structure of the ISM model offers valuable insights into the factors influencing food waste reduction in the AFSC. By understanding the interdependencies and addressing factors at various levels, stakeholders can implement effective strategies to minimize food waste and enhance overall sustainability in the agricultural and food supply chain.

- **Autonomous Region I**

  According to Figure 4, there are no factors present in the autonomous region.

- **Dependent Region II**

  Quadrant-II in Figure 2 represents the dependent factors in the context of the AFSC (Agricultural and Food Supply Chain). These factors include Processing Capability (F5), Distribution Network (F9), Consumerism (F6), and Supply Chain Coordination (F4). Although these factors have weak driving power individually, they are strongly interdependent and rely on each other for effective management. In India, the AFSC is characterized by its dispersed nature and lack of ownership. Companies striving to reduce food waste along the supply chain face operational and relationship-related inefficiencies. The development of capabilities, alliances, and efficient supply chain networks is facilitated by information technology. However, external constraints such as food policy, legislation, and market infrastructure can hinder their implementation. When it comes to understanding consumer behavior in relation to food waste, the Theory of Planned Behavior (TPB) proposed by (Siqueira et al., 2022) has been widely utilized in various contexts. The TPB considers attitudes, norms, perceived control, and intentions as predictors of behavior. Researchers such as (Azlina et al., 2013) have applied the TPB to explain food waste separation behavior at home, incorporating situational factors as an additional construct. Their study accounted for 13.7 percent of the variance in the intention to separate, suggesting that other factors beyond those considered in the study also influence intention. Similarly, (Graham-rowe et al., 2015)hodges explored household food waste reduction using an extended version of the TPB. They found that attitudes, subjective norms, and perceived behavioral control predicted the intention to reduce fruit and vegetable waste in households. Their final model explained 8 percent of the variance in food waste reduction behavior. These studies demonstrate the utility of the TPB in predicting consumer behavior related to food waste. However, it is important to acknowledge that additional factors beyond the TPB constructs play a role in influencing intentions and behaviors regarding food waste reduction. Further research is needed to comprehensively understand the various factors and dynamics involved in addressing this issue. In conclusion, Quadrant-II in Figure 2 highlights the interdependent factors of Processing Capability, Distribution Network, Consumerism, and Supply Chain Coordination within the AFSC. In India, the AFSC faces operational and relationship-related inefficiencies, which can be addressed through the development of capabilities, alliances, and efficient supply chain networks facilitated by information technology. Understanding consumer behavior regarding food waste reduction has been aided by the Theory of Planned Behavior, although additional factors beyond its constructs also influence intentions and behaviors. Further research is necessary to gain a comprehensive understanding of the factors affecting food waste reduction in the AFSC.

- **Linkage Region III**

The factor identified as Technical Support (F3) is categorized as a linkage factor in Quadrant-III of Figure 2. It holds significant driving power and dependence within the context of the AFSC. Improvements in several areas, such as enhancing supply chain functions, making cross-functional decisions, coordinating at supply chain interfaces, measuring and diagnosing food waste, and managing customer interactions, are all influenced by the technical skills of individuals, effective communication, utilization of tracking technology, and the presence of adequate technical support. The complex nature of food qualities and the lack of clarity in the AFSC necessitate the involvement of information technology. Technical support plays a crucial role in addressing these factors by providing the necessary expertise, guidance, and resources to enhance supply chain operations. This includes leveraging technological advancements to improve communication, data tracking, and analysis related to food waste management. To optimize the AFSC, it is essential to develop technical competencies among personnel involved in the supply chain. Their skills in utilizing tracking technologies, effectively communicating and coordinating across different interfaces, and employing technical support systems can greatly contribute to reducing food waste and improving overall supply chain performance. Additionally, the utilization of information technology enables better measurement and diagnosis of food waste, facilitating targeted interventions and informed decision-making. By employing appropriate technical support systems, organizations operating within the AFSC can enhance their understanding of food waste-related issues, identify areas for improvement, and implement effective strategies to mitigate food waste throughout the supply chain. In summary, Technical Support (F3) serves as a crucial linkage factor in Quadrant-III of Figure 2 within the AFSC. Its strong driving and dependence power make it vital in addressing various aspects such as enhancing supply chain functions, cross-functional decision-making, measuring and diagnosing food waste, and managing customer interactions. The utilization of technical skills, communication, tracking technology, and information technology are key factors in addressing these factors and achieving optimization within the AFSC.

- **Independent Region IV**

Processing Capability (F5), Supply Chain Uncertainty (F2), Policy and Framework (F8), and Inefficient Infrastructure (F7) are identified as independent factors with strong driving power but weak dependency on other factors. These factors are considered the key obstacles hindering the reduction of food waste in the Indian AFSC (Agricultural and Food Supply Chain), as highlighted by (Priefer et al., 2016). Stakeholders and policymakers aiming to reduce food waste can focus on diagnosing and addressing these dominant factors to achieve more successful outcomes. Technologies can play a crucial role in mitigating these factors at the production and distribution levels. For instance, technology can be employed to influence factors such as perishability, quality variation, seasonality, and bulkiness of food. Examples include implementing production practices under regulated temperature, lighting, or irrigation, cultivating crop types that provide commercial harvests earlier and extend the seasonal pattern of yielding, and utilizing chemicals to delay crop maturity. However, a significant limitation in the Indian farming industry is its fragmentation, limited access to financing, education, and training, as well as the inability of small farmers to invest in new technologies. The increased utilization of these technologies also facilitates closer collaboration among manufacturing, processing, and distribution operations, which helps to reduce supply chain uncertainty, including demand, supply, price, and process uncertainties. Technological advancements enable the substitution of natural raw materials during processing with specially formulated fat, sugar, beverage, and other product substitutes. By reducing the need to synchronize processing with agricultural production, process uncertainty is also diminished. Computerized storage and monitoring of commodities during transit can enhance both physical commodity and informational flows, provide early quality control warnings, and alleviate supply-demand mismatch, thereby countering price volatility. Additional technologies employed during processing and distribution stages encompass aseptic packing, vacuum and polyethylene packaging, ultra-high temperature processing, and controlled atmosphere storage and transport. However, upgrading the inefficient market infrastructure, which includes complex market systems, inadequate cold chain and supply, and poor operational facilities, requires substantial long-term investments that are currently impractical. Currently, only 2% of the produce grown in India undergoes processing, and the majority of food is improperly stored and transported using non-refrigerated vehicles, while trading facilities remain scarce. In India, weak food policies and regulations exacerbate food waste resulting from insufficient market infrastructure and limited technology adoption. Inadequate food policies, poor regulatory frameworks, and a lack of quality and safety measures contribute to the problem. Inadequate food policies and regulations lead to a lack of social responsibility among the stages in the AFSC, as they fail to take preventive actions against food waste. The exact quantity of food waste is currently unknown. To encourage waste reduction, it becomes necessary to implement explicit punishment and reward systems that link the level of investment (risk) to the associated rewards. Similar to Western countries, India is experiencing increasing urbanization, and grocery chains are expanding, as noted by (Rands et al., 2010). In conclusion, addressing the factors of Processing Capability, Supply Chain Uncertainty, Policy and Framework, and Inefficient Infrastructure is vital for reducing food waste in the Indian AFSC. Technological interventions can play a significant role in enhancing supply chain operations, managing perishability and quality variations, and reducing uncertainty. However, the fragmentation of the farming industry, limited resources, and inadequate market infrastructure pose significant hurdles. Strengthening food policies and regulations, as well as implementing punishment and reward systems, can encourage waste reduction and promote social responsibility. Addressing these key factors will be essential in effectively tackling food waste in the Indian AFSC and promoting a more sustainable and efficient food supply chain.

CHAPTER 5
CONCLUSION

Food security and environmental impacts can both be improved and reduced by minimizing food waste. The 'main' issues preventing the decrease of food waste in Indian AFSC were found to be Processing Capability, Supply Chain Uncertainty, Policy & Framework, and Inefficient Infrastructure. By concentrating on and identifying these issues, AFSC enterprises can realize significant benefits. They limit the judgements made at the three decision-making echelons and each of the supply chain tiers.

Farmers should receive the appropriate instruction on the processing techniques and technology required. All of the information that is accessible needs to be shared, and the tools that are available need to be used effectively. The problem with product distribution can be resolved by enhancing communication between the various supply chain components.

Due to variations in regional climate circumstances, there may be differences between the results obtained and the actual situation. There may also be variations in the methodology used to analyze the factors. Additionally, the views of specialists differ greatly from subject to subject and from product to product because one group specializes in academics, while the other is versed with real-world situations. This sector's outcomes cannot be generalized to other streams.

Nine significant issues that contribute to waste in AFSC are identified and modeled in the current research endeavor. Figs. 2 and 3 display the same's structural model. Processing Capability, Supply Chain Uncertainty, Policy and Framework, and Inefficient Infrastructure were found to be the 'main' factors preventing the decrease in food waste in Indian AFSC.

5.1 Limitations, future scope of the study, and managerial implications

It should be highlighted that the weighting guidelines differ greatly by sector, and the corresponding results are solely applicable to the agriculture food supply chain and cannot be generalized to all other industries.

To implement the ISM technique effectively, one has to be well-versed in the methodology, have the necessary training to evaluate the data produced, and access to computers (Sushil, 2012). The relation between the factors totally depend the on the judgments of the person's knowledge, and the inputs given by the experts could be biased (Jolhe & Babu, 2014). To surmount these impediments and to enhance the accuracy of the model or for the purpose of validation, integrated approach may be used (Gardas et al., 2017). Tools which can be employed along with the ISM approach are interpretive ranking process (IRP), technique for order preference by similarity to ideal solution (TOPSIS), analytic hierarchy process (AHP), analytic network process (ANP), decision making trial and evaluation laboratory (DEMATEL), structural equation modeling (SEM), interpretive structural modeling (ISM) (Raut et al., 2017).

Nine classified elements are taken into account in this study, although there may be additional factors that are not included but still have the potential to induce wastage along the supply chain. Other research' results will be improved by including more variables. The authors would like to use a structural equation modeling methodology to validate this model in the future.

India is among the top three Agri-food producers in the world and contributes only 1.2% to the global trade (Sagheer et al., 2009). The primary cause of the lower percentage share is wastage, which occurs across the entire supply chain, costs farmers money, lowers the product's quality and nutritional value, and eventually raises its price. Therefore, it is crucial to employ the appropriate policies, tools/techniques, and technology in order to reduce or even completely eliminate post-harvest losses. The identification of the most significant factors causing waste will help to reduce the same.

By choosing the appropriate temporary storage, transportation, and distribution network, the losses can be minimized. A significant amount of waste can be avoided by employing trained labor for the activities of loading and unloading agricultural products. Farmers need to receive the appropriate education regarding post-harvesting technology and their management. The identification of the significant gaps and their elimination through the application of appropriate corrective measures, as well as the creation of waste management procedures, are crucial. The underprivileged farmers can be inspired to compete on the world market.

In agricultural supply chains, reducing post-harvest losses is crucial for the socioeconomic and environmental aspects. It is a multicriteria decision-making dilemma with strategic implications. This study offers a methodical approach to help supply chain managers and other decision-makers better comprehend the problems relating to the supply chain's post-harvesting component. Additionally, the crucial elements are recognized and modeled. The ISM model and the power matrix provide insightful data. This model aids participants at various supply chain levels in determining the contributing elements and formulating effective mitigation strategies. It is possible to analyze the time frame for the same, as well as the tools and strategies needed to cut losses and boost effectiveness. It is important to note that reducing post-harvest losses generates income and, in the short- and long-term, balances ecological and social elements. Additionally, it enhances market share, ensures stakeholder loyalty, makes businesses more competitive, lowers energy consumption, lowers product costs, and boosts the region's employment potential.

CHAPTER 6
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APPENDIX

- ## Questionnaire

Final Year Project

Collage: Jss Academy of technical education, Noida

Department: Mechanical Engineering

Project: Food and waste supply chain management

Introduction

- Food waste in India poses significant factors to the agri-food supply chain.
- Inadequate infrastructure and storage facilities contribute to post-harvest losses.
- India loses or wastes around 30-40% of its total agricultural produce annually. (Source: Food and Agriculture Organization)
- Transportation inefficiencies lead to spoilage and wastage of food during transit.
- Approximately 5-15% of fruits and vegetables in India are wasted during transportation. (Source: Ministry of Food Processing Industries, Government of India)
- The lack of cold storage facilities results in significant spoilage of perishable produce.
- Around 30% of fruits and vegetables and 35% of marine products in India go to waste due to inadequate cold chain infrastructure. (Source: National Centre for Cold-chain Development, India)
- Inefficient distribution systems create imbalances between food surplus and deficit regions.
- Approximately 21 million metric tonnes of wheat are wasted annually in India due to storage and distribution issues. (Source: Indian Council of Agricultural Research)
- Food processing units generate substantial waste during processing and packaging.
- These introductory bullet points, along with the corresponding statistics, provide a comprehensive overview of how food waste affects the agri-food supply chain in India.

Q.1) Relationship between

A) Preparation error
B) Supply chain uncertainty

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.2) Relationship between

A) Preparation error
B) Technical support

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.3) Relationship between

A) Preparation error
B) Supply chain coordination

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.4) Relationship between

A) Preparation error
B) Processing capability

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.5) Relationship between

A) Preparation error
B) Consumerism.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.6) Relationship between

A) Preparation error
B) Inefficient infrastructure.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.7) Relationship between

A) Preparation error
B) Policy and framework

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.8) Relationship between

A) Preparation error
B) Distribution network.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.9) Relationship between

A) Supply chain uncertainty
B) Technical support.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.10) Relationship between

A) Supply chain uncertainty
B) Supply chain coordination
.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.11) Relationship between

A) Supply chain uncertainty
B) Processing capability.
.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.12) Relationship between

A) Supply chain uncertainty
B) Consumerism.
.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.13) Relationship between

A) Supply chain uncertainty
B) Inefficient infrastructure.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.14) Relationship between

A) Supply chain uncertainty
B) Policy and framework.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.15) Relationship between

A) Supply chain uncertainty
B) Distribution network.
.
- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.16) Relationship between

A) Technical support
B) Supply chain coordination
.
- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.17) Relationship between

A) Technical support
B) Processing capability
.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.18) Relationship between

A) Technical support
B) Consumerism
.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.19) Relationship between

A) Technical support
B) Inefficient infrastructure.
.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.20) Relationship between

A - Technical support
B - Policy and framework.
.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.21) Relationship between

A) Technical support
B) Distribution network.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.22) Relationship between

A) Supply chain coordination
B) Processing capability

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.23) Relationship between

A) Supply chain coordination
B) Consumerism.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.24) Relationship between

A) Supply chain coordination
B) Inefficient infrastructure.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.25) Relationship between

A) Supply chain coordination
B) Policy and framework.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.26) Relationship between

A) Supply chain coordination
B) Distribution network.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.27) Relationship between

A) Processing capability
B) Consumerism.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.28) Relationship between

A) Processing capability
B) Inefficient infrastructure.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.29) Relationship between

A) Processing capability
B) Policy and framework.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.30) Relationship between

A) Processing capability
B) Distribution network.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.31) Relationship between

A) Consumerism
B) Inefficient infrastructure.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.32) Relationship between

A) Consumerism
B) Policy and framework.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.33) Relationship between

A) Consumerism
B) Distribution network.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.34) Relationship between

A) Policy and framework.
B) Distribution network.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.35) Relationship between

A) Inefficient infrastructure
B) Distribution network.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.

Q.36) Relationship between

A) Policy and framework.
B) Distribution network.

- A affects B.
- B affects A.
- Both affect each other.
- They have no relation.